# Manual on Economic Development Projects

UNITED NATIONS

# MANUAL ON ECONOMIC DEVELOPMENT PROJECTS

UNITED NATIONS
*New York, 1958*

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E/CN.12/426/Add.1/Rev.1

UNITED NATIONS PUBLICATION

Sales No.: 58.II.G.5

Price: $U.S., 3.00; 22/6 stg.; Sw. fr. 13.00
(or equivalent in other currencies)

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## EXPLANATION OF SYMBOLS

Three dots (...) indicate that data are not available or are not separately reported.

A dash (—) indicates that the amount is nil or negligible.

A blank space ( ) in a table means that the item is not applicable.

A minus sign (—) indicates a deficit or decrease.

A space is used to distinguish thousands and millions (1 346 849).

A full stop (.) is used to indicate decimals.

A stroke (/) indicates a crop year or fiscal year, e.g., 1953/54.

An asterisk (*) is used to indicate figures partially or wholly estimated.

Use of a hyphen (-) between dates representing years, e.g., 1950-1954, normally signifies an annual average for the calendar years involved, including the beginning and end years. "To" between the years indicates the full period, e.g., 1950 to 1954 means 1950 to 1954, inclusive.

References to "tons" indicate metric tons, and to "dollars" United States dollars, unless otherwise stated.

Details and percentages in tables do not necessarily add up to totals, because of rounding.

The initials "ECLA" refer to the Economic Commission for Latin America.

## PRELIMINARY NOTE

During its fourth session, which was held in Mexico in June 1951, the Economic Commission for Latin America adopted resolution 4 (IV) which refers to "the common need of all Latin American countries for fundamental research, and for the training of Latin American economists in the field of economic development", and which recommends the establishment of an ECLA study centre for the economic development of Latin America in consultation with the United Nations Technical Assistance Administration.[1]

Pursuant to this resolution, the present ECLA/TAA Economic Development Training Programme was organized; it has been in operation at Santiago, Chile, since 1952 and the important part which it plays has already been recognized by the Governments members of the Commission.

The execution and development of the Programme are bringing into increasing prominence a problem which was already acknowledged to be acute *per se*: the almost total lack of a Spanish bibliography in this field, which could be of assistance not only in improving the quality of the courses given under the Programme but above all in attaining the more ambitious and infinitely more important objective of spreading throughout Latin America an understanding of the scope and nature of development problems and of the methods and techniques available for solving them.

Slowly but surely the Economic Commission for Latin America has been fostering a consciousness of such problems in the region and has drawn attention, in its studies, to the over-all and individual solutions proposed. In the series entitled *Analysis and projections of economic development,* an introduction to the technique of programming was first outlined,[2] and it was later applied to specific countries.[3] In manner of speaking these studies constituted an initial approach to development problems, but their final objectives could only be attained by supplementing them with manuals, presenting in clear, coherent and concrete terms, information and knowledge hitherto widely dispersed. Students of economy—as well as, and above all, the technicians and officials working in our countries—need a tool that can be forged into an efficient working instrument. Such is the objective, in the field of investment projects, of this *Manual,* published by ECLA and TAA as the fruits of their joint efforts in the Latin American economic sphere.

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[1] Official Records of the Economic and Social Council, Thirteenth Session, Supplement No. 8, E/2021 (E/CN.12/266), pages 18-19.

[2] E/CN.12/363, United Nations publication, Sales No.: 1955. II.G.2.

[3] Studies on the economic development of Brazil (E/CN.12/364/Rev. 1), Sales No.: 1956.II.G.2, Colombia (E/CN.12/365/Rev.1), Sales No.: 1957.II.G.3, Argentina (E/CN.12/429 and Add. 1-4) and Bolivia (E/CN.12/430 and Add. 1/Rev.1), Sales No.: 58.II.G.2.

# PREFACE

A project is defined in this *Manual* as the compilation of data which will enable an appraisal to be made of the economic advantages and disadvantages attendant upon the allocation of a country's resources to the production of specific goods or services. The present study attempts to explain what is meant by "economic advantages and disadvantages", what data can be used to determine them, and the methods whereby such data can be obtained and systematized.

It should be noted in the first place that economic appraisal implies forecasts and that this inevitably involves risks as regards their accuracy. It is common knowledge that some of the hazards or contingencies confronting any enterprise can be determined, but this does not take into account the miscalculations made at the various stages of the study of a project which may be so serious as to doom the project to failure. Even when a margin of error is allowed in computing costs, it must be remembered that the estimates contained in a project relate not only to costs, but also to the volume of demand, prices, the reactions of the consumer, the development of the goods or services in question, possible technical innovations, consumer preferences and many other variables dealt with hereafter. It can therefore be asserted that allocating resources for the installation and operation of new units of production of goods or services involves what is usually termed a "calculated risk". This means that it is necessary not only to decide to take the risk, but also to base such a decision on a rational analysis of the possibilities of success according to the soundest available data and premises. This background information should be taken into account when studying the investment project.

It is true that, however carefully prepared a project may be, it cannot fully cover all the factors which affect it, nor can it anticipate all the difficulties which will have to be overcome on the spot with respect to its organization, initiation and operation. But a project does represent the rational basis for the decision to set up an enterprise, and hence it must be studied as thoroughly as possible. Moreover, well documented projects may help to arouse interest in their execution, and their prospects of attracting the attention of potential initiators will be commensurate with the quality of preparation and presentation.

The disparaging comments which are often heard regarding the standard of some of the investment projects originating in under-developed countries indicate that, if the economic advantages of the relevant investment schemes were satisfactorily presented, the co-operation of foreign capital, so urgently needed, could be obtained more easily, or on a larger scale. Furthermore, substantial losses are constantly being registered both in the public and in the private sectors because the best available method of attaining a given production target is not selected or because a plan is embarked upon which should never have passed beyond the study phase.

Such shortcomings may be due largely to the fact that what constitutes a good investment project study is not always clearly understood, and to the shortage of trained personnel qualified to organize, direct or inspire the required studies. The potential practical and concrete value of this *Manual* lies in the contribution which it may make towards eliminating these shortcomings.

The problem has been duly appreciated in the economic development training courses organized jointly by the United Nations Technical Assistance Administration and the Economic Commission for Latin America. With this recognition, however, came the discovery that there is a surprising shortage of didactic material to assist the teachers and pupils in these courses, or to serve later as a guide in their practical work.

Preliminary enquiries made in the various technical circles connected with the practical aspects of economic development confirmed the almost complete lack of methodological textbooks to assist engineers and economists in the preparation of projects, and further emphasized the need for a study of this type.

For these reasons, it appeared to the above-mentioned United Nations organizations that this *Manual* on the preparation, presentation and evaluation of investment projects should be compiled.

In this study, projects are not regarded as isolated economic units; they are considered within the context of the entire economic system of which they will form a part. Thus the *Manual* presents both macroeconomic and microeconomic concepts. From this it must not be inferred that the *Manual* attempts to offer a combined microeconomic and macroeconomic theory. It seeks to contribute more to an appreciation of the problem than to its solution, thus widening the outlook of those who prepare projects so that they may make the greatest possible compilation of useful data for their economic appraisal.

In the preparation of this *Manual*, special attention has been paid to public projects, whether intended for implementation by that sector or for later handing over to private entities once the promotion and development is completed. The contents will nevertheless be of use in the preparation of any project, whether by the public or private sector since any differences lie more in the direction of the economic appraisal criteria than in the type of information which must be compiled, elaborated and presented in studies of this type.

It is not hard to appreciate the difficulties involved from this outline of the problem. An attempt must be made to produce a combined presentation of both technical and economic principles, and to include within the latter the economic concepts of a single enterprise and those of the wider economic field. The first chapter develops the conceptual theory of the *Manual* and explains its structure; it is therefore unnecessary to go further into these matters in this preface. Instead, the reader will be warned that he must not expect any new contribution to the theory of allocation of resources, nor to a solution of the problems of the single enterprise, such as market studies, site, size, or preparation and analysis of estimated income and expenditure budgets. The first part, which deals with the material which must be included in a project, attempts to suggest a coherent arrangement of this type of material, which is available in specialized books and publications, and also cites a number of references to enable readers to widen their knowledge of any particular subject of special interest to them. The second part, which is devoted to the criteria for allocating priorities, explains the problem clearly and expounds the better-known points of view on the subject.

A good study of a project requires the combined efforts of a team of engineers and economists, whose work must be complementary. Although this may appear to be a detail, in practice it is of considerable importance, since the best techniques for the elaboration of projects will be valueless unless the team works on a basis of mutual understanding. Any project will be the creation of its authors, just as a building is the creation of its architect. There are architectural standards, styles and techniques in the preparation of plans, but the ultimate result will be the creation of the technicians who draw up those plans.

This *Manual* presents certain standards, theories, cases, examples and explanations of the method of preparing projects, but the most important part of a study will always be the contribution of those who carry it out. This is true not only because the subject is too vast and complex to permit of precise and invariable standards, but also because it is impossible to foresee all the local circumstances which might affect a particular project; some flexibility is essential in applying the general standards laid down in the *Manual*. The preparation and presentation of a project must of necessity be the personal creative work of its authors, rather than a routine application of formulae and theories. The *Manual* has merely assembled and systematized in the clearest possible manner many scattered and apparently unconnected, although individually well-known facts. The engineer and economist will therefore encounter in the book more than one section which is completely familiar to them. They had to be included in the interest of uniformity and coherent arrangement in order to fufil the object of the *Manual* and to serve a greater number of readers. The reader will always find an explanation, however brief, of the various subjects covered in the project and thus will not have to refer to other publications for clarification.

The explanations of demand and elasticity in the chapter on markets may seem superfluous to the economist, but he must remember that it is quite possible that the engineer is not familiar with these concepts and that it will be easier for him to have an explanation immediately to hand than to have to seek it in textbooks on economics, which in any event would not deal with the subject from the point of view of the study of investment projects. Similarly, in some of the examples it was considered necessary to add technical appendices to explain technical terminology familiar to the engineer but not always understood by the economist. Thus what is superfluous to one reader will be useful to another.

Assuming that all the participants in the study are co-operative, there is one further requisite: There must be a leader. This is an elementary administrative principle in commercial enterprises, but it is not always appreciated in the case of study groups. It is best to appoint a responsible person from the start vested with the administrative and professional authority to give a ruling on points of doubt or discrepancies which may arise in the course of the study.

The following pages explain why the process of preparing projects consists of a succession of approximations. The precise function of the leader of the group is to direct this process; he should request the research and information needed to arrive at a final decision. The nature of this process and the type of studies required constitute the subject of the first part of the *Manual*. The second part shows how to compare the decision arrived at with those reached in other project studies, so that priorities may be allocated.

It is generally believed that the preparation of projects and the allocation of priorities are separate activities involving different types of training: the first would be the responsibility of the engineer, and the second of the programme planners. Yet this separation is not so clear-cut as might at first appear, and even in the preparation of a project it is necessary to decide between alternatives which may have a far-reaching effect on the general development programme and on the allocation of resources. As an illustration, it is sufficient to bear in mind the greater or lesser capital intensity which a project will allow, in order to understand why a decision cannot be made on the basis of a technical criterion alone.

Those who allocate priorities cannot therefore limit themselves to choosing between projects as they are presented to them; they must also know the history of the various technical alternatives and how the final decision was reached. On the other hand, those who prepare the background information and who have to decide on the technical alternatives, must also know—or at least have a general idea about—the problems of those responsible for allocating priorities for the employment of resources.

The subjects dealt with in the *Manual* may therefore interest all those whose activities are related to investment projects. An attempt is made not only to offer methodlogical guidance to those directly participating in the study of projects, but also to those who must assess and pass judgement on them. To be brief, it is hoped that these pages will be useful to the engineers and economists who prepare projects, to the heads of public departments or private enterprises who must assess the quality of projects presented to them, and to the senior financial executives, public and private, who must decide on the allocation of resources and priorities. It is not over-ambitious to hope that the *Manual* will serve such a varied group of readers. The *Manual* is broad in scope because a broad approach was adopted towards the subject in view of the undeniable inter-relationship of the individual project and the economic whole.

Confirmation of the increasing interest in the subject is found in two recent works which unfortunately could not properly be utilized in the *Manual*, but which are of interest not only because of their authors but also because of their sponsors. The International Bank for Reconstruction and Development (IBRD) called upon Professor Jan Tinbergen to prepare a study on the problem of priorities of individual projects as related to economic development programmes.[1] The other noteworthy contribution is entitled *How to select dynamic industrial projects*, in which the selection of projects is treated as a part of industrial development and is determined by means of inter-industrial analysis. This research was sponsored by the United States Government, through the International Cooperation administration.[2] Both these studies confirm the basic con-

[1] Jan Tinbergen, *The Design of Development*. A report for the International Bank for Reconstruction and Development, Washington D. C., 7 February 1956.

[2] *How to select dynamic industrial projects*, prepared for the International Cooperation Administration by the Council for Economic and Industry Research Inc., Washington, D. C.

tentions of this *Manual*: that projects must be judged on the basis of their relationship to the remainder of the economy.

In view of the difficulties experienced in finding a sound method of presenting and developing the subject it has been considered advisable to explain the topics in the order in which they arise in the project: market, size and site, engineering, investment, budgest and the organization of data for evaluation and financing. At the end of the first part a chapter has been added summarizing the project.

Finally, it appears necessary to explain the criteria adopted as regards the presentation and selection of the cases used as illustrations in the *Manual*. Although there is an immense variety of projects and possibilities, there are practical limitations in the way of publishing all the material available and each practical example quoted has to be dwelt on at some lenght. This is the reason why every point in the study is not illustrated with practical examples.

The illustrations were taken from specific cases, and care has been taken to describe them with the maximum accuracy compatible with the needs of the illustration. Due acknowledgement must be made here of the valuable co-operation of the International Bank for Reconstruction and Development and of the Export-Import Bank of the United States, which provided practical material of very considerable interest, on the basis of which many of the examples were prepared. Acknowledgement is also due to many enterprises which authorized the use of private information. In each case, only those parts of the study which seemed most successful were used, so that the examples do not cover complete projects but only certain aspects of them. Since it is very difficult to isolate one part of a project from the remainder, it was necessary in each case to give a brief summary of the pertinent details, or to use in one single example two or more aspects of the same study, which created problems regarding its place in the text (for instance, the techmical description of a project and the computation of investments).

Warning must be given that the figures used in the examples quoted are pleliminary estimates made at the time of the study. They may therefore be valid no longer and must not be considered to bear any relation to the present status of the enterprises. But, this has no importance from the point of view of the *Manual*, whose object is to present not figures but methodology.

Because of the practical difficulties arising from lack of information or from the specific circunstances of a certain project, the treatment of the problems is not always precisely as recommended. The projects were not prepared purely for instructional purposes, but for execution, and for this reason the final presentation may not include the details which justify certain omissions or which have determined the method of approach to a problem. In view of these circumstances which confront the planner, a neutral position has been adopted and the cases have been presented without critical comment. The only way to produce a sound critical commentary would involve a basic study of each project, which is impossible.

Part One

# THE SUBSTANCE OF A PROJECT

## Chapter I

# PROBLEMS AND GENERAL CONCEPTS

### I. Techniques of programming economic development

There is growing consensus of opinion in under-developed countries that economic development should not be left to the vicissitudes of the economy, but that, on the contrary, it requires a deliberate effort directed specifically towards accelerating the rate of increase of *per capita* income.

Hence it is necessary to approach the economic development problem as a whole, from its basic theoretical and conceptual aspects to its practical and executive phases. This field of research and study includes both global and partial programming techniques, and those related to the preparation and evaluation of individual investment projects. The problem of economic development also includes important associated questions relating to economic policy and to the administration and organization which will formulate and execute the programmes and co-ordinate Goverment action in relation to the development objectives. The preparation of projects is the final phase in the formulation of development programmes and the connecting link with the practical stage of execution. It has been considered advisable to begin by presenting a theoretical framework in order to situate the project within the programming process, and later to explain the nature of the study of the project itself. These introductory pages also include some ideas relating to the selection of possible projects.

#### 1. *The project and the over-all view of the programme*

It is important to recognize the fact that projects must always be related to an appreciation of the economy as a whole. When it is decided to invest capital in a given scheme, certain suppositions are accepted—even though only by implication—regarding the economic development of the area or country concerned. The most scientific way of examining and formulating such suppositions is to use a technique of programming. In any event the point of departure is an over-all appreciation of the economic panorama and, although the method and extent of such an appreciation may differ, the fact is that the individual project is not conceived in a vacuum, but rather in an atmosphere in which it can thrive and to which it must contribute. Thus the existence of this relationship should be recognized and investigated systematically, instead of being left to intuition. The limitations imposed by the resources available for investment make this recognition both necessary and important, which partly explains the increasing interest of under-developed countries in development programmes.

It must be admitted that a formal and systematic development programme is not an indispensable condition, desirable though it may be, for the study and execution of individual projects. Projects are often made with only a simple, superficial and almost intuitive appreciation of the economy as a whole, and under these circumstances there are various modes of procedure. For instance, it is possible to have only an "idea" and some cost estimates and to decide to invest on this basis; the idea can also be developed extensively and thoroughly studied. The latter method involves a careful analysis of the repercussions and interrelationships of the project and a more detailed investigation of its advantages and disadvantages in relation to the economy as a whole, which again necessitates a general appreciation.

In many cases widely diverse projects have been executed in Latin American countries without any of the studies or analyses described in this *Manual* either of the economic whole or of the individual project. Indeed it is often argued that, if the projects had been delayed until all the necessary studies had been completed, most probably many of them would never have been executed. This may be partly true. In the early stages of development, the requirements are simpler, since the economic and social structure is not complicated. Apart from the development of certain activities, mainly connected with primary production to meet domestic demand and to supply the foreign currency needed for the rest of the country's requirements, or both, most of the available resources are invested in public works and buildings. There is no clear definition of economic development problems, and decisions are made on the basis of these simple social-economic factors. As development proceeds, however, investment alternatives are less obvious, and there is increasing social pressure for an improved standard of living. It is at this stage that citizens of initiative set up their enterprises, without any extensive economic studies, relying rather on their economic instinct or their knowledge of the market. At times this instinct is rewarded; at other times it is not. Since the enterprises which succeed are the only ones which survive, it is easy to use them as examples of success without highly complicated studies. At the same time, if the failures were studied, a different picture would be presented. In many of these meagrely studied projects, the same results are achieved as in some mines; three or four entrepreneurs lose their money and their hopes but the fifth strikes a rich vein at the first drilling. Thus the system of trial and error finally produces a successful enterprise where there were only failures before. Many of the failures could have been avoided by adequate prior study, which would either have forewarned the entrepreneurs of the difficulties or would have caused them to abandon the project.

It should also be remembered that in some cases an enterprise has survived because, once established, it was a *fait accompli* and thus obtained an unjustified degree of protection and tax relief, which in the final instance resulted in a burden on the community as a whole. The more thorough the analysis of the relationship between the project and the remainder of the economy and the better the quality of the studies, the less is the risk of failure or of incurring the unnecessary social costs involved in badly evaluated projects.

To sum up, the more complicated the economic structure, the greater the number of investment alternatives and the less evident the choice. Plain intuition, or the will of enterprising men, is no longer sufficient. This will and initiative can be assisted greatly by coherent development programmes and by good preparation and presentation of projects: If there is no specific plan in the shape of a development programme, the object of which is to ensure a proper allocation of resources, the only basis for allocation will be the studies of individual projects, which makes it doubly necessary to prepare them with extreme care.

The first task, therefore, is to situate the project within the general pattern of the development programme, a point which requires detailed explanation.

### 2. *Programming*

The basic object of programming is to obtain a wide perspective of the economic development of the country or of the area, so as to establish co-ordinated production targets compatible with the stability of the system. This perspective provides a point of reference, which in turn enables more detailed studies to be made of sectors and specific projects, and supplies the basic criteria for the establishment of the financial, monetary, foreign trade, salary, wage and other policies which will ensure the success of the plans. Programming includes, firstly, an analysis of the historical trends of economic development, and what may be called a diagnosis of the present situation. This analysis shows the changes which have taken place in the economy and their causes, and at the same time enables an appreciation to be made of possible future development, always assuming that the various factors continue to have the same effect.

Once this basic analysis is made, a coherent plan of production targets can be formed, compatible with stability, in order to achieve the rate of development considered possible under existing conditions and in the light of the knowledge obtained regarding renewable capital assets and natural, human and financial resources.

The inter-relationship of the over-all and sectorial objectives must be reflected in the projection of a system of national accounts and of production by sectors compatible with the demand structure and with the anticipated development of foreign trade. The volume of investment must thus bear a relationship to the volume of savings and of foreign capital; at the same time, the amount and composition of these investments must be such as to enable the production target for each sector to be attained. The projection of the balance of payments poses fundamental problems of coherence and stability. Which part of the demand will be met from domestic production, and which from imports? What import substitution or increase in the volume of exports, or both, will be necessary to maintain equilibrium in the balance of payments, assuming that some foreign investment will be forthcoming? In this brief outline, mention might also be made of the problems created by possible migration and labour productivity in programming development. Increased industrial activity implies, amongst other things, a migration of labour from the country to the town and increased productivity, which produces a series of repercussions on the structure of demand and the composition of investments. It also makes necessary an analysis of the employment problem and of the possible surpluses which may arise in the labour force if the rate of development is not sufficient to absorb the extra manpower resulting from the increase in population or the virtual surpluses in the primary sectors. These points show some of the fundamental problems inherent in programming development: the importance of ensuring coherent objectives, the type of over-all perspective which may be obtained, and the advantages which may be gained if individual initiatives are kept within this perspective.

Irrespective of whether or not a systematic and rational investigation is made of the possible production targets, the system will develop in such a way that there will be some compatibility between the economic variables (production and income, investment and savings, balance of payments, public and private consumption, etc.). The real problem is to avoid achieving this balance at a high social cost and with a waste of the available resources.

The programme will reveal the nature and extent of possible structural changes in the development, and will present a series of problems connected with the financing, the institutional framework and the economic policy necessary for the achievement of the objectives. This means that an adequate organization must be available to implement the programme, to formulate financial and foreign trade policies and to draw the dividing line between the public and private sectors, so as to create the conditions which will encourage the entrepreneurs to carry out their part of the programme.[1]

Thus, for instance, the taxation system must cover the financing of investments in the public sector; it must provide adequate tariff protection for industries which require it; it must exempt the industries to be encouraged from taxes, and tax more heavily those to be discouraged.

The amount of detail in programming, and in the techniques used to develop a coherent and practicable pattern, may vary widely. Whatever technique is used, it must include a process of successive approximations, in order to produce the first outline of the programme, and a process of continual revision and adjustment to events, new information, data and experiences accumulated with the passing of time.

From the point of view of the implementation of the programme, the measures adopted will finally show that certain specific projects should be carried out and that the resources available should be channelled in a definite direction.

As has been seen, the two main outlets to be distinguished in the first place are the public and private sectors. Hence, two types of decisions are necessary: (*a*) allocation of the resources necessary to finance certain projects in the public sector; and (*b*) adoption of a practical economic policy which will encourage entrepreneurs to invest in the most desirable direction in accordance with the programme. It is here that the study and comparison of the projects in the programme and the relationship between a project and the programme have their greatest effect.

[1] The concept of a development programme is often confused with one of rigid State control of the economy. There may be considerable State intervention without the objective of economic development, while at the same time a programme may be put into effect with a minimum of direct State interference. To establish a dividing line between State and private action does not necessarily imply concentration of the maximum investment in the public sector. In fact, it is possible that joint action for economic development may provide a renewed stimulus to private enterprise by supplying basic services whose production is not attractive to the private entrepreneur; this might be the aim of taxation, credit or other policies designed to provide reliable and cheap electric power and means of transport.

### 3. *Programmes and projects*

The need for co-ordination and the policy decisions involved in any programme call for an analysis of various alternatives and the establishment of some hypotheses as a starting-point in the study of the objectives, in order to make a first approximation of the volume of investment, demand and imports, and of other fundamental factors.

The sole purpose of over-all projections is to determine the trend of investments and of national economic policy, to indicate the basic lines of future action and to produce approximate figures for the constants and the variables of economic development in accordance with the economic pattern adopted. When specific projects are studied and more detailed information is available, some items of the programme may be corrected to bring them into line with the new information. Projects are thus a link in the process of successive approximations involved in the technique of programming and an important element in the flexibility and continuous revision of the programme.

When individual investment projects are studied, more definite information is available on natural resources, capital requirements and labour, sites, and other aspects of the creation of new productive units. With this more complete knowledge the initial hypothesis can be confirmed or rectified, and more suitable objectives formulated. The over-all outlook provided by the programme supplies a criterion for the selection of projects which should be prepared and studied in relation to the objectives. In turn, the study of individual projects will influence the formulation of objectives and the policy of the programme, thus establishing a continuous process of revision and adjustment.

The manner in which the information derived from studies and the technique of programming complement each other may be seen, for instance, in estimates of demand and investments and in the selection of the scale of production in a project. When preparing an over-all programme, probable future demand for goods and services is estimated by using the same concepts as for investigating the demand in individual projects. There is one important difference, however: whereas in programming the projections of demand are applied in most cases to a group of goods, in the individual project they are applied to one single item (or to a few, if it affects a larger industrial system). The market study must therefore be more specific and more closely defined in the case of a project; a project could, for instance, employ all the research methods which have been developed for marketing studies.

The first approximation of the estimated volume of investment is based on coefficients which measure the product-capital ratio, that is to say, the relation between output and the investment necessary to obtain it.[2] In many cases, these coefficients will be calculated for groups of products and will therefore show weighted averages which are valid for the group but not for each component item. On the other hand, aggregate coefficients can only be established from statistical information relating to past events. Many important changes may have taken place since the statistics were compiled and, although these may not seriously affect average coefficients over a short term, they do influence individual projects. By studying these projects, direct and up-to-date information will be obtained for each product, which takes into account the influence of existing or foreseeable technical innovations. This detailed information enables quantitative estimates of investments in the programme to be verified or rectified in relation to the coefficients. Modifications which may result from this comparison are part of the process of successive approximations and continuous revision of the programme mentioned earlier. In order to prepare the annual budgets and the investment programme, it is always essential to possess precise information on each project, since apart from the priorities established by the over-all programme, there is also a time priority problem, the solution of which is aided by specific studies of each project. In addition, at the practical phase of execution, it is essential that the specific budget on which the programme has to operate should be already approved.

Similar remarks apply to scales of production and the indivisibility of equipment in general. During the first formulation of the programme, when the subject of achieving a certain production target is discussed, it is impossible to foresee all the problems which will arise from the minimum or maximum production scales of each enterprise. These problems can only be approached when more precise information is available concerning the market, site, minimum production scale and other details which appear in projects but which are not foreseen in global projections of the economy as a whole.

Another important aspect of the inter-relationship between projects and programmes is the selection between the various technical alternatives for the production of determined goods or services. Suppose, for example, that programming studies indicate a clear priority for allocating resources for the production of electric power. There is still the problem of selecting the technique to be used to generate this power, assuming that the alternatives are thermal (coal, oil or gas) or hydro-electric power stations. The adoption of a coal-burning power station would evidently have completely different repercussions on the remainder of the economy from those resulting from a hydro-electric station, and would have a very different effect on the structure of the programme. It might, for instance, involve the allocation of additional resources to open up coal mines, or to install means of transport for the coal. The technical alternatives can only be analysed on the basis of studies of the individual projects.

These studies also help to define more clearly the lines of economic policy. A policy of tariff protection or other means of encouraging certain domestic production may be adopted in principle, but this decision must be confirmed in practice by calculating the incentive, and defining the items to which it refers. Study of the projects provides the information needed to justify such decisions of economic policy, to convert them into specific terms, and to avoid indiscriminate or unjustified protection.

There are also some purely practical relationship between a programme's global objectives and the study of projects, which are of particular interest to enterprises that may be developed by the private sector. For instance, well-studied projects may provide a valuable incentive for suitable channelling of savings, thus activating the executive capacity of the entrepreneurs. A serious, well-presented and intelligent demonstration of a project's advantages may lead to the formation of savings, and accelerate the movement of capital between the various sectors.

[2] From the product-capital ratio the amount of installed capacity required to achieve a specific production target can be determined. The difference between this amount and existing capacity shows the volume of new investment necessary to achieve the target.

In other cases, the amount of interest derives from the fact that the community understands that some projects — whose study would be difficult or too costly for the private entrepreneur, to whom the community would prefer to entrust them—can be taken up by government bodies; they may simply study these projects, or study and carry them out, or finance studies wholly or partially by research institutes, or in fact enter into various combinations with the private sector, either at the study or the execution phase. Incidentally, this *Manual* has been written with particular reference to projects in the public sector; at the same time, it is hoped that the substantive material will be equally valid for those preparing projects in the private sector. The process of elaboration is the same for both; the differences only arise in relation to the criteria which must be applied for economic evaluation.[3] Finally, it must be remembered, in connexion with these practical questions, that one of the functions of individual projects is to foresee possible difficulties in installation and operation, and to provide timely solutions. Administrative, financial, transport or any other type of difficulty, if not taken into account in time, may cause delay or the complete failure of large projects, jeopardizing the entire programme. Programmes are to projects what building plans are to construction materials. In the long run, the best plan cannot succeed if poor materials are used.

[3] See Part Two for further comment on these criteria.

## II. Choice of projects to be studied

Because of the wide variety of possible projects, and of the practical limitations to studying them all, a good selection of initiatives has to be made. This leads to the problem of establishing criteria and methods for making this selection. Strictly speaking, this is more a problem of general programming technique than one relating to the study of individual projects; however, in view of the close relationship between projects and programmes, and the frequent absence of technically prepared programmes, it may be useful to include in this chapter some ideas which may serve as a basis for selecting possible projects, remembering that investment initiatives must always be subject to some form of general examination of the economy. The project selection criteria given below do not mutually exclude one another, and should be considered as suggested methods to be adapted to the circumstances of each problem; the greater the care given to studying the framework into which they will fit, the more useful they will be.

### 1. *Projects based on sectorial studies*

Once it has been decided to carry out a programme by economic sectors, preference has to be given to projects referring to the corresponding sector: agriculture, transport, etc.

### 2. *Studies based on an over-all development programme*

If an over-all development programme exists, its projections and production targets will provide the pattern for selecting the projects to be studied. Two criteria which are not mutually exclusive may be used to select possible projects: the first is based on considerations of technically associated projects which may be called "technical compexes", and the other on projects associated by a location factor, which may be called "geographic complexes".

In the first case, a list should be made of possible projects in each sector, and the lists later compared in order to re-form them in technically integrated groups. For example, if the programme includes the installation of an iron and steel industry, the need to study the project would become evident when projecting the manufacturing sector's targets. At the same time, it would also be necessary to study the supplementary projects for producing coal, limestone, etc., which are in the primary production sector.

Similarly, if the programme includes the substitution of imported newsprint by domestic production using the country's own natural resources, the industrial project would appear on the list of manufacturing projects, but would also be dependent, by virtue of derived demand, on forestry, road, rail and electric power projects, pertaining to the primary or services sectors. By selecting groups of projects on the basis of this technical criterion, "production complexes" can be determined which serve as a guide for preparing a series of specific projects.

It may also be useful to approach the problem from the angle of the programme's geographic or territorial aspects. Once production targets in each economic sector have been defined and the location of the basic natural resources ascertained, groups of projects can be formed on a regional basis. For example, in the case of a paper industry based on domestic forests, the location will be determined from the start, and this project can then be combined with others which for obvious reasons will also be established in the region, so as to form well-integrated geographical complexes.

The complexes thus deduced from the territorial and technical analyses can next be compared with a view to drawing up a final list of specific projects for study.

### 3. *Projects based on market studies*

Market analyses by themselves may suggest a number of possible projects. In under-developed countries, such possibilities may be outlined as follows:

(a) *Export markets for goods which the country is specially qualified to produce*

Cases in point are Brazilian coffee, Chilean copper, Cuban sugar and, broadly speaking, those goods which are exported directly or are manufactured from raw materials characteristic of the country in question. When production has already reached high levels, the central problem for possible projects of this kind will be the absorption capacity of the world markets. Given the existence of the natural conditions described, and of reasonable market prospects, new projects could be studied which take advantage of these circumstances.

(b) *Export markets for goods whose production does not depend upon exceptional natural conditions*

These would be goods and services which can compete in the world markets, even when natural conditions in the country are not especially favourable for their production. Examples are the manufacture of rayon in Cuba, the Mexican film industry and others. These examples show that it is not advisable to discard *a priori* the possibility of developing production for which there is an insufficient domestic market, and which must compete on the world market. In many cases a variety of circumstances arises, permitting the successful development of a new activity which can compete on these markets. Thus, for instance, special access to the United States goods and capital markets has allowed Puerto Rico to develop many manufactured goods. However, it is not sufficient that such facilities should exist—full advantage must be taken of them.

Projects developed on the basis of domestic markets may increase their output to supply neighbouring markets by taking advantage of certain geographic circumstances, or they may supply other under-developed countries through complementary agreements. This type of agreement is particularly important, since it may make all the difference between efficient production at a high level and production on an uneconomic scale, or even no production of certain goods.

(c) *Import substitution*

Substitution of imported goods and services normally constitutes one of the greatest possibilities for developing domestic production. A careful examination of import statistics can provide the basis for selecting possible projects, considering in a first approximation the quantum of specific imports, and the minimum economic scale for producing them.[4]

(d) *Substitution of artisan by factory production*

An analysis of the possibilities of replacing artisan and cottage manufacture by factory production may lead to the study of a series of specific projects. From the national point of view, the total substitution of this type of activity cannot be expected, nor would it be advisable. Certain forms of artisan production—handicrafts, repair work, home weaving—have their own importance. At the same time there are others which could be converted with advantage to factory production, thereby contributing to the general raising of labour productivity.

[4] Great importance is attached to import substitution and industrial development in the theoretical presentation of the development problem published by ECLA. See *Economic Survey of Latin America, 1949* (E/CN.12/164/Rev.1) United Nations publication, Sales No.: 1951. II.G.1, and also *Theoretical and Practical Problems of Economic Development*, (E/CN.12/221) United Nations publication, Sales No.: 1952.II.G.1.

(e) *Increase of domestic demand*

The increase in the demand for goods and services already supplied by domestic enterprises will depend basically on population growth, the increase in the level of income, and prices. A forecast of these increases in demand and a study of marketing methods may also suggest a study of specific projects.

(f) *Unsatisfied demand*

Even without the need for a thorough examination of markets or of natural resources, the known existence of bottlenecks or of the necessity to anticipate requirements for basic services, will also provide data for selecting possible projects. This will often occur in the electric energy and transport sectors.

### 4. *Projects based on other natural resources*

Apart from those already mentioned, examination of other natural resources will also suggest possible projects if preliminary results appear to justify a more detailed analysis. This type of project may also result from technical innovations giving potential value to resources which were previously considered worthless.[5]

### 5. *Political and strategic projects*

Finally it should be mentioned that many projects are studied and executed for reasons of State or national urgency. Military strategy, territorial problems, political pressure or unemployment difficulties may necessitate the study of specific projects varying according to the circumstances. Further comment on this subject will be made when dealing with evaluation criteria.

[5] Uranium mines undoubtedly provide a very good example of this.

## III. Nature of project studies

The execution of a project introduces a dynamic factor into the country's economy which will have repercussions on the whole system. Some ideas should therefore be put forward as to the precise meaning of the word project as used in this *Manual*, and the scope of the studies which it comprises.

### 1. *Stages of a project*

Ideally, the process of preparing and selecting possible projects should pass through the following stages: (*a*) selection of the projects; (*b*) preparation of preliminary projects which will justify allocation of resources for further studies; (*c*) preparation of preliminary projects to determine preferences between the various possibilities; (*d*) allocation of priorities between the projects studied; (*e*) preparation of the final projects; (*f*) installation of the new productive units; (*g*) entry into operation and normal operation of the productive units.

Stages (*b*), (*c*) and (*e*) relating to the study of preliminary and final projects are the subject of the first part of this *Manual*. Stage (*d*) leads to the economic evaluation problem, which is dealt with in the second part of the *Manual*. Stages (*f*) and (*g*) cover the execution of the project, once the studies are completed, and although they are of importance to the success of the enterprise, do not present any conceptual problems as regards the elaboration of the project itself.

### 2. *Technical and economic phases of a project*

At the study stage, a project may be described as the aggregate of information which permits appraisal of the advantages and disadvantages of the allocation of economic resources—also called inputs—to a productive centre or unit, where they will be transformed into goods or services. If it is decided to proceed with the enterprise, an execution stage commences, and the project becomes the aggregate of information and plans which will permit the installation of the production unit. At the study stage, the economic aspect is the principal consideration, whilst at the installation stage it is the technical aspect.

In practice, as stated in the outline, the first part of the study should be known as the preliminary project, reserving the name final project for the second stage. The word project is often used indiscriminately to describe both phases, the precise meaning depending on the subject to which it refers. A brief review should therefore be made of the technical and economic aspects of the study in relation to the concepts of preliminary and final projects. All projects have a technical and an economic phase, which are closely connected, and which have a reciprocal effect; the project improves in quality in direct ratio to the degree of technical-economic liaison achieved; this again emphasizes what has already been said regarding team-work between engineers and economists.

Once all the studies forming a project have been completed, the term "project engineering" can be used to cover the technical aspect, and "project economy" to describe the purely economic phase of the investment project, the reciprocal influences mentioned above being implicit in these definitions. This distinction is only adopted for descriptive purposes, since in fact there is only one project, which combines the two aspects in a harmonious whole. In the case of manufactured goods, for instance, the project engineering would be that part which describes the technical operating process of the industry, the quantity and quality of the various raw materials and finished products, transport and power requirements, the size and layout of the industrial buildings, etc. On the basis of these elements the required investment is calculated, work programmes are prepared, the timing of these two items is organized, and production costs are estimated. Finally, all these elements must be weighed in accordance with certain economic criteria, so that the desirability and feasibility of the enterprise may be assessed and an investment project drawn up.

The transition from the technical to the economic phase is not so smooth as might be expected from this explanation. Naturally, there would be little object in speaking of the technical project *per se,* independently of the problem of allocating resources to meet a certain demand; it would be equally pointless to allocate resources for a given line of production without recognizing the existence of certain technical requirements. The close inter-dependence between technical and economic aspects goes beyond the general approach to the problem. Furthermore, even in the partial aspects of the study, each technical alternative also involves an economic alternative. The use of fuel "A" or "B" does not only signify the adoption of a certain technique, but also the existence of definite economic advantages or disadvantages; similarly, mechanization of loading, transport and unloading of materials constitutes both a technical and an economic problem.

There is therefore no natural sequence for the technical and economic aspects during the study stage—both must be considered simultaneously. Nevertheless, once the two aspects have been basically defined, after joint discussion, the project will have a clear-cut technical phase, in which the economic elements are incorporated, and a purely economic phase, which involves a complete analytical evaluation of the project, including the technical factors.

Obviously, the degree of precision in the economic phase must be closely related to that of the technical phase. In order to reach a decision, all the technical details of physical installation are not necessary; the engineering studies should merely contain sufficient information to permit the formation of an economic opinion on which to base priorities. The figures will obviously change somewhat when the studies become more detailed, and later, when the project is executed, but this is of no importance so long as the changes do not substantially affect the economic substance of the preliminary project.

There is a wide range of interpretations of the meaning of preliminary project. In the preceding outline a distinction was drawn between the preliminary report for the purposes of deciding whether or not to assign the funds for more detailed studies and the research necessary in order to justify economic investment. The degree of precision required in the studies would vary in each particular case. In this respect, the judgement of the authors of the project is specially important in view of the limited number of experts available for such work. In fact, waste of resources and of experts' time in carrying studies beyond the precise degree of approximation required is unjustified. It must therefore be the technicians themselves who decide the extent of the studies in each case. It is this single decision which finally sets the seal on the preliminary project.

Except where otherwise stated, the term "project" will only be used hereafter to denote a preliminary project, that is to say, "a study with sufficient data to appraise the economic merits of an enterprise but without the detail necessary for its execution".

### 3. *The project as a dynamic centre*

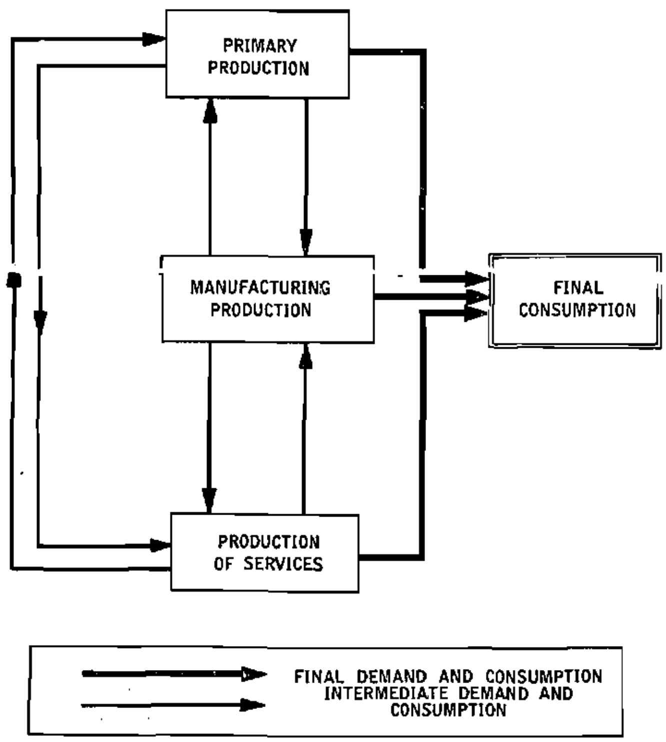
The outline plan for transforming inputs into goods and services, which is used to define a project, has repercussions in two general directions. One may be called "backward", or "towards the source". This relates to the inputs required by the project which give rise to what in technical parlance may be termed "problems of derived demand". The other may be called "forward", or "towards the destination". This relates to the course and final destination of the goods and services to be obtained from the new unit, and is linked to market studies.

Seen in broad perspective, a project pre-supposes that its execution will have both direct and indirect effects. The direct effects consist only of the first link in the chain of relations which the project establishes (payment for inputs and sale of products), whilst the indirect effects are the remaining links both backwards and forwards (From where, and at what price will the inputs be obtained? What course will the goods and services follow, once acquired by the first purchaser?).

In the case of the derived demand, it is advisable to distinguish between that originating from the installation of the productive unit and that resulting from its operation. The type of resources for the two stages, and the resulting practical supply problems, are quite different, even though they form part of one whole—the project itself. The relative importance of the two stages varies according to the type of project; in road-building or the construction of hydro-electric plants, the derived demand problem largely arises in the early stages. In manufacturing industry,

**FIGURE I**

SIMPLE DIAGRAM BY SECTORS




however, the demand arising from its operation is considerable, and the smaller the fixed investment in relation to output, the greater will be the derived demand.

In short, the wider concept of the project must cover both direct and indirect effects, and the repercussions on the economic system, both forward and backward, of its installation and its operation throughout its useful life.

This concept is useful for establishing priorities between projects on a wider basis and in greater perspective. Many enterprises are only economically justified when the broader aspect of their relationship to the remainder of the economy is considered. These possibilities and forms of inter-relationship are shown in a simple graph which allows them to be examined in conjunction with the variety of activities which may be projected (see figure I). It shows the three great production sectors: primary, manufacturing and services. The primary sector consists of mining, agriculture, fishing and forestry. Services include transport, power, marketing, communications, financial operations, etc. Finally, the manufacturing sector, assisted by the services, transforms raw materials from the primary sector, creating an immense variety of manufacturing activity.

Each of these sectors produces two types of article: one for final consumption and another to meet the demand of the same or other sectors. Thus, within agricultural production, one part consists of foodstuffs consumed by the farmer and his family, or sold directly to the final consumer, whilst the other is kept for seed for later production; yet another could be sold as raw material to the manufacturing sector, and finally a part may be required by the services sector. Similarly, part of the manufactured production may be sold directly to the consumer, part to the same sector, or to both, whether in the form of intermediate or capital goods. The same type of example may be given for the services sector.

By considering a specific project in any of the three sectors, a clearer picture may be gained of the type of relationships which it may originate, and of the adjustment. In the preparation of projects, these relationships and repercussions must be studied thoroughly, both backwards (derived demand) and forwards (market); moreover, the adjustment problems arising from the execution of the project must be forecast, together with the advantages which it may offer to other enterprises.

### 4. *Special types of projects*

In spite of the wide variety of possible projects, there is a common conceptual frame within which the subjects dealt with in this *Manual* have been encompassed. Special mention will be made only of the cases of multiple projects and those of services which are not marketed. The former are those which combine in a single study several types of projects. A typical case is the control of river basins, where simultaneous examination is possible of proposals for water control, irrigation, generation of electric power, navigation, supply of industrial or drinking water, erosion control, fishing, etc. The explanations in the text are easily applicable to this case. The special problem involved is the allocation of investment and production costs between the various partial aspects of the multiple project.[6]

The study of projects for production which is not marketed—such as the building of schools for free education—may also be approached by the general methods described in this *Manual*, but the volume of demand and the extent of the services produced cannot be appreciated in monetary values. For this reason, priority problems and decisions on this type of project are related more to questions of general policy and vision than to comparison of specific coefficients of evaluation. This subject will be discussed further in the section on market studies.[7]

[6] See Part One, chapter V, on project investments.

[7] See Part One, chapter II.

## IV. Essence of a project

As already stated, the purpose of a project is to systematize and present the data necessary for an economic appraisal. It has been explained that the first part of the *Manual* will cover the nature of this data, and the methods which may be used to obtain, systematize and present it. The second part will deal with the manner of utilizing this information to establish the comparison with other projects, that is, for the economic evaluation of the project.

### 1. *Fundamentals of the project*

As is done in Part One of this *Manual* the subjects covered in a project may be grouped in chapters according to a common layout, although the importance given to the various points will depend upon the nature of the project or the local circumstances. These chapters are: (*a*) study of the market; (*b*) determination of size and location; (*c*) project engineering; (*d*) calculation of investments; (*e*) budget of annual expenditure and income, and arrangement of the data for evaluation; (*f*) financing; (*g*) organization and execution.

The order in which these subjects have been placed is only a suggestion as regards presentation, and bears no relation to the order in which they may be studied. Since there is considerable inter-dependence between them, the study of the project is in fact commenced simultaneously along various lines, arriving at the presentation of final solutions by means of a system of successive approximations.

First, a brief explanation will be given of the contents of the chapters of this first part and later some of the relationships between them will be indicated; the remainder will be explained when dealing in detail with the problems of each.

*Market.* Chapter II will cover the study of the demand for the goods or services involved in the project. It consists essentially in determining how much can be sold, and at what price, specifying the characteristics of the product or service in question and approaching the problem of marketing and associated subjects.

*Project engineering.* Chapter III will include a technical description of the project, and will enter into questions of preliminary technical research and engineering problems which will arise in the project; the selection of manufacturing processes; the specification of equipment and buildings, and the justification of the degree of mechanization adopted; the quantity and quality of inputs required; the technical problems and flow diagrams covering the installation and operation of the project; work schedules, and in general the plans, drawings and graphs which will assist the explanation and improve the presentation.

*Size and location.* Chapter IV will explain the determination of production capacity which must be installed, and the location of the new productive unit.

*Investments.* Chapter V will deal with the calculation of the total investment in national and foreign currency required for the project, taking into account both the invesment in fixed assets and in working capital.

*Budget of income and expenditure, and arrangement of the data for evaluation.* Chapter VI will present an estimated calculation of the costs and income which will result from the operation of the enterprise. It will also include in systematic form the information which may be required to evaluate the project, such as the effect on the balance of payments, budget and availability of labour; discussion or justification of the exchange rates used in the calculations, and other points whose discussion and analysis comes before the true economic evaluation. An examination will also be made of the incidence of variations in the percentage of capacity installed and actually used, in the exchange rate, in selling prices, and in other significant factors.

*Financing.* The sources of financing are specified in Chapter VII, together with the manner in which it is proposed to channel these resources for the execution of the project.

*Organization and execution.* Chapter VIII explains the proposed solutions of the problems of legal constitution of the enterprise, and the organization for the execution of the project.

A few examples should be sufficient to indicate the relation between these matters. It is obvious that the volume of demand to be satisfied will have a very considerable influence and will at times be the determining factor—on the decision as to the capacity of the new productive unit. But the size of the market will depend, amongst other things, on the location of the enterprise, so that there is a definitive relationship between size, location and the market. On the other hand, selling prices will sometimes greatly influence the volume of demand. These are almost invariably dependent upon production costs, which in turn are a function of the scale of production and location. Hence, there is a further relationship between the market, size and location of the enterprise, and the costs and income budget of the project. Additional reciprocal relationships appear when it is considered that technical production alternatives (engineering) often depend upon the scale of production (size), on the financial resources available (financing) or on the type of available raw materials (location). Financing problems may in turn affect decisions regarding size, again with repercussions on all the remaining factors. Thus the size of the project cannot be decided without knowing the volume of the demand, without discussing engineering problems, or locality, or without an estimate of the necessary investment or production costs. At the same time, to elucidate each one of these points, the size of the project must be known. Thus, a vicious circle is formed, which can only be broken by a series of successive approximations. In practice, there are always factors which limit the degree of liberty in the study. But the presentation of the problem leads to its solution by approximations, various initial hypotheses being adopted until the best possible formula is reached from the point of view of the evaluation criterion selected for the qualification of the projects.

### 2. *Evaluation*

The fundamental object of any economic study of a project is its evaluation, that is, to assess its quality and to compare it with other projects according to a certain scale of values in order to establish an order of priority. This task involves a definition of what are called "advantages and disadvantages" of the allocation of resources to certain ends. In other words, the comparison standards to be used, and their method of application must be established.

Obviously, an attempt will always be made to emphasize the advantages and to minimize the disadvantages, but both will vary qualitatively and quantitatively, depending upon the evaluation criterion employed. The theoretical problem of establishing what evaluation criterion should be used to establish priorities has not yet been definitely solved; the various theories which exist and which have been applied will be explained in the second part of the *Manual*. It may be mentioned here that only two will be considered; comparison standards from the point of view of the private entrepreneur, and those from the point of view of the community as a whole, which may be called social evaluation criteria.

The problem of economic evaluation of projects lies in deciding what are these differences, and why they exist; which are the representative criteria of each type, and how they may be reduced to figures.

# Chapter II

## STUDY OF THE MARKET

### I. Introduction

#### 1. *Definitions*

The object of a market study in a project is to estimate the volume of goods or services provided by a new productive unit which the community would be disposed to acquire at given prices. This volume represents the demand from the point of view of the project, and it is specified for a conventional period (a month, a year, or other period). Since demand normally varies with price, the estimation should be made for various prices, always remembering that the enterprise must cover costs and make a reasonable margin of profit.

This free interpretation of the problem certain concepts and limitations which should be explained here, in order to simplify the exposition which follows. The fundamental concepts—what is understood by demand in a project study, what is the definition of the word "market", and what is the difference between a "market study" and a "marketing study". The limitations lie in the fact that not all goods and services are marketed.

The market has been defined as "the area where the forces of supply and demand operate in order to establish a single price".[1] For the purposes of this *Manual,* that definition must be interpreted in the wider sense of the existence of a group of individuals whose requirements demonstrate the supply and demand situation leading to the establishment of a price.[2] Hence, the necessity arises of defining what group of people is covered by the study in question.

Normally, these groups are defined geographically, and market studies refer to definite territorial areas, to the whole country, or to any region of the world.

Knowledge of the distribution of consumers throughout a given geographical area will influence both the volume of demand and the location of the enterprise. A good location may both decrease prices and increase the demand.

The difference between market and marketing studies must also be clarified. In this *Manual,* marketing will be understood to mean the flow of goods between producers and consumers, which will be considered as a partial aspect of the market study. The latter will also include an analysis and projections of the demand.

#### 2. *Demand in a project study*

In order to define the concept of demand in relation to a project, a distinction must first be made between the total volume of transactions in determined goods or services at a certain price, and the demand which would exist for the production of the project under study. That volume would represent the total demand, which is what must be known, but the ultimate object is to determine the volume of goods or services from the new productive unit which the market is capable of absorbing. If the total existing demand is not met, the output of the project will be added to that of other suppliers, and there will simply be an addition to the volume of transactions on the market, and the study will therefore be directed to quantifying the unsatisfied demand. The possible existence of an unsatisfied demand can be seen from two general types of indicators, one of prices, and the other of the establishment of some type of controls. If there is an unsatisfied demand for certain goods or services, and there are no price controls, prices will reach very high levels compared to production costs, i.e., there will be abnormally high levels of profit for the suppliers of these goods or services. On the other hand, if price controls or rationing, or similar measures have been established, it means that at those prices there is an obvious unsatisfied demand, which it is hoped to deter by means of these controls.

It may also occur that the new production will not increase the volume of the market, but will simply displace other suppliers. The demand will be met by substitution of other goods or services. Such would be the case where there was a demand for better quality goods or services than those currently offered on the market, which would make possible the displacement of the present suppliers. There may also be a project introducing new techniques in order to reduce costs and thereby achieve a price advantage over other similar products; in this case, there would not only be a redistribution of the market between suppliers, but also a possible increase in demand resulting from the lower prices.

If the displaced suppliers were importers, then the project becomes one of import substitution. Projects designed to increase exports may be based both on the satisfaction of an unfulfilled demand and on the displacement of other international suppliers.

The volume of any of these possible forms of demand in relation to the project may make it possible to install one or more production centres. Decisions to this effect will depend largely on the geographical boundaries of the market, that is, the locality of the demand. From this is derived one of the fundamental relationships between the market study, the size and the location of the project.

#### 3. *"Free" services*

"Production units", also include schools, hospitals, roads, and other constructions which are not always marketable. The fact that the services obtained from the operation of a school, or from the use of a highway, generally have no market price since they are supplied "free" by the

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[1] Paul H. Nystrom, *Marketing Handbook,* The Ronald Press Co. New York, 1948.

[2] Another meaning is the precise place where commercial transactions occur.

state or the municipality must not be interpreted to mean that there is no demand, or market, for these services.

For example, in under-developed countries there is an obvious unsatisfied demand for educational or health services. The fact that this type of demand is not expressed as a market requirement makes it more difficult to estimate its volume, and the advantages of allocating resources to satisfy the need. An examination will be made later of the procedures which may be used to form an idea of the magnitude of the demand for these "free" services.

The use of the term "free" services is merely conventional. The air is free, because its use does not involve the sacrifice of another type of production which would require that air. On the other hand, a hospital or a school represents a social cost, since the resources used to build a hospital could have been employed to meet a need other than health. Thus the so-called "free services" are only nominally so, and the community actually pays for them in real terms by sacrificing other goods, and in financial terms, although indirectly, through taxation or other means.

### 4. *Stages in a market study*

As in other studies, that of the market includes two stages: the collection of data and the establishment of empirical bases for their elaboration and analysis. The analysis and elaboration stage must answer the fundamental questions of the study: How much can be sold? At what price? What are the marketing problems of the product?

The replies to these questions must embrace the present and future demand throughout the project's useful life[3] and will be satisfactory or otherwise, depending not only on the quality of the available data, but also on the degree of efficiency of the theoretical instruments used for the analysis of the demand. There are serious limitations in the methods used to project the volume of demand and prices; some general indications will be given, although recognizing the inadequacy of the working instruments available for any projection worthy of complete confidence. In this respect it is useful to remember always that any investment project presupposes a calculated risk.

The problems of analysis of demand have received conplicated economic theories have been evolved which are beyond the scope of this *Manual*.[4] It is not intended to offer here a complete presentation of the technique of market studies, but only to indicate some methods which may be useful for the solving of simple cases. For more complicated cases—and if the scope of the project so warrants—it will be necessary to seek the services of specialized consultants.

[3] The concept of useful life is related to the time required to exhaust reserves covering depreciation and obsolescence (see Part One, chapter VI).

[4] See, for example, Hernan Wold, *Demand Analysis*, John Wiley and Sons, New York, 1953.

### 5. *Over-all approach*

In the light of the foregoing observations, the problem may be outlined as follows:

(*a*) Since the purpose of the project is to supply the community with certain goods or services, it will be necessary to estimate the volume of these which are to be produced, and which the community will acquire at predetermined prices.

(*b*) The new production will be added in some cases to the present volume of movement; in others, it will only replace a part or all of the goods or services from other domestic or foreign sources.

(*c*) The determination of the volume of demand is only operative at predetermined selling prices; these latter also affect the volume of income estimated in the project's income and expenditure budget.[5]

(*d*) From the previous points it may be deduced that the essence of the market study is to supply criteria useful in deciding the capacity to be installed in the new productive unit, and to estimate possible income during the project's entire useful life. In many cases, the first objective will not require a very elaborate analysis of the demand, but an approximate estimate of it will at least be necessary. As regards prices, although a projection may present serious theoretical and practical difficulties, it is essential that it should be made for both input and output of goods and services.

(*e*) The compiling of data on marketing and the influence of economic policy will establish the bases of the study, since it will indicate in each case the most important variables which affect the volume of demand and prices. If rationing, subsidies, protective tariffs or other factors affect the market for the goods under study, the analysis of the demand must include a hypothesis as to their future operation, thereby converting them from variables into parameters.[6]

(*f*) With the information obtained and the working hypotheses adopted, certain theoretical premises could be established in order to quantify the present and future demand for the project under study. These premises refer essentially to the "demand function".

In accordance with this plan, the first task is the compiling of data, and the methods to be employed; next will come the explanation of some basic theoretical premises in the analysis of the total present and future demand; finally the problem of estimating which part of the present and future demand will be met by the project will be discussed, in the light of the conclusions and forecasts derived from the marketing study and other information.

[5] See Part One, chapter VI, section III.

[6] This is not always made sufficiently clear in the study of a project, but in any case it will be implied. The simplest market study, although without any of these apparent "refinements", includes an assumption regarding the permanence or probable duration of certain economic policies or forms of marketing which, naturally, influence the market. It may again be repeated here that the decision to investigate more deeply any particular circumstance depends upon the planner's judgment.

## II. Collection of data and methods used

### 1. *Aims of this stage of the study*

The data to be compiled for the market study include the pertinent statistics and also the characteristics of the market in so far as they concern disposal, legal provisions, standardization, price controls or other factors which have a significant effect on the volume of demand and the prices of the goods under study. This differentiation between statistical and non-statistical data is of course conventional and adopted merely to facilitate the argument.

The statistical data will be used to calculate certain coefficients employed in the analysis of demand, such as income and price elasticity. The other data will serve to qualify these estimates and establish reasonable hypotheses on marketing conditions, rationing, price and similar controls, which may prevail in the future.[7]

The relative importance of the various data will vary according to the aim of the study and the type of goods to be examined. It will be for the investigator to decide where further research is necessary, where specialized help will have to be called in to obtain better information on certain matters, and where a detailed study can be dispensed with in favour of an approximation. On him also will depend the period which the research covers. Usually the bulk of the information should date back a relatively long time. Generally speaking, 10 or 15 years will be enough to allow the regression or trend curves to be used in the analysis, in spite of the economic upsets which may have occurred during this period. The aim is to eliminate estimates affected by abnormal circumstances influencing relatively short periods and arising from a specific set of events.

Finally, the international market situation should be considered in the light of the goods under study. At the same time, the repercussions of the project on both the international and domestic markets should be analysed. Here, it may be necessary to reconcile the project with the requirements of existing treaties and agreements or with a possible policy of international economic complementarity.

### 2. *The data*

The main data referred to above are as follows:

#### (a) *Statistical series*

Any market study of goods or services must begin with the compilation of statistical series of production, foreign trade and consumption. Data on production, imports, exports and inventory changes make it relatively easy to determine whether consumption figures are correct or not. Lack of information often leads to "apparent consumption" being accepted as true consumption; the former is obtained by subtracting the difference between imports and exports from the total production, and it may differ widely from true consumption if there have been any notable changes in stocks. In most studies of easily preserved agricultural goods, the use of apparent instead of true consumption figures may lead to serious errors, although there are cases where the use of the apparent figure would have no appreciable effect. This would be the case, for instance, for perishable consumer goods. It must be remembered that possible losses during marketing could produce erroneous results in the estimates of demand and consumption based only on figures of production, imports and exports.

The above series must be accompanied by price series; these should include quotations at the three most important levels at which transactions take place: (i) original price; (ii) price paid by the wholesale distributor; (iii) price paid by the consumer or user. For manufactured goods the original price is f.o.b factory and for agricultural commodities it is f.o.b. farm. Imported goods should be quoted as f.o.b. port of embarkation or c.i.f. port of destination.[8]

In the case of prolonged historical research, adequate price indices will have to be established to determine the relative prices of the particular goods and services.[9]

For econometric analysis, national income and population series are necessary in order to establish the correlations referred to below.

The most-used sources of information are official statistics, censuses, special studies by economic research institutes or other national or international bodies, information obtainable from private firms, import and export data normally published by Governments, and road, rail and other transport figures. If these sources are inadequate or deficient, research in the field will be necessary. Its scope will depend on the nature of the project, on the funds which may reasonably be allocated for this purpose, and on the accuracy of the figures to be used in the study.

#### (b) *Uses and specifications of the goods or services to be produced*

This aspect of the study is designed to set forth the specifications or characteristics which define precisely the goods or services under review and the exact uses to which they will be put. It must also indicate who will use them and how they will be used. If, for example, steel is to be produced, it may not be sufficient to establish that there is an over-all demand for a certain number of tons per year; the qualities, shapes and sizes which must be produced must also be known in order to decide on the manufacturing equipment required.

The process of industrialization involves the establishment of technical levels of quality and standardization of goods, which must be considered in the study. In the case of products for export, it must be remembered that the standards accepted for the market may vary from one country to another; the problem will then be closely linked to the geographical location of demand. The meeting of standards may be a requirement of law or simply of the market, which rejects sub-standard products. From the practical point of view there is no difference. Even in the absence of legal stipulations, failure to meet the preferences of the market would result in such a low sales price as to make the project impossible.

#### (c) *Prices and costs*

Knowledge of selling prices to wholesalers and end-users enables estimates to be made of distribution costs. It is also useful to find out the profit margins of importers. If these are large, importers will be able to grant an internal discount and thus ruin any new enterprise seeking to substitute the imports concerned. Reliable information on production costs and their main components will also be helpful. Such data will give a picture of the real profit margin and the competitive position of the new enterprise or project on the market. Finally, the prices of products

[7] For example: the prior solution of certain transport or storage problems, provision of additional installations such as refrigerator plant or other enterprises which facilitate marketing.

[8] The expression f.o.b means literally "free on board" but it is more commonly used to mean "placed at". The expression c.i.f. indicates that the cost of freight and insurance is included. The expression f.a.s. means "free alongside ship".

[9] Relative prices are obtained by deflating nominal annual prices by these indices.

competing with the one under study should be ascertained since they might eventually become substitutes for it.[10]

(d) *Types and idiosyncrasies of consumers*

The knowledge of the quantity of goods and services which can be absorbed by the market at any given moment must be supplemented with information on the characteristics of consumers. In the first place, it is important to distinguish between consumers of finished products, of intermediate products (those which will be transformed by their purchasers), and capital goods, which are used to make other products.[11]

In the case of consumer goods, one important aspect is distribution by income levels. The higher-income brackets differ from the lower in their consumer habits. It is also well-known that, as regards low-income consumers, marginal articles are unstable when there are violent economic fluctuations. On the other hand, those goods and services which account for the greater part of consumers' expenses are those which fluctuate least.

All these characteristics may have a notable effect on the industry which it is proposed to establish, and must be taken into account in the study.

It is also interesting to know the consumers' reactions to the presentation of the product, their reaction to the methods of its use (which in the case of fish, for example, may have considerable importance), or their reaction to advertising. To obtain this information it is almost always necessary to resort to surveys or some similar method; these techniques will be described later.

(e) *Sources of supply*

It is also indispensable to know the present sources of supply of the goods or services, and if they are foreign or domestic. In the latter case, it is as well to enquire into existing production capacty, how far it is being used, where it is located, and the characteristics of typical productive units. These may be, for instance, inefficient artisan or small-scale enterprises, which may be replaced by a factory of adequate size, using modern techniques.

If an attempt is made to substitute foreign supplies, it would be helpful to find out how the price of the imported product is made up, so as to determine the real possibilities of competition or the desirability of substitution. Furthermore, consideration will have to be given to the questions of international trade previously mentioned.

(f) *Distribution mechanisms*

As previously stated, marketing is understood to include all activities related to the circulation of goods and services, from the production site to the end-user.[12]

The marketing study also helps to define the specifications of the goods which the community requires, and the knowledge of consumer preference.

In under-developed countries this part of the problem may not have the same importance as in large industrial centres. But as the economy develops and becomes diversified, and as more people begin to spend money and to make their demand known through the mechanism of the market, specialized studies of the ways and means of meeting this demand become more important. It is beyond the scope of this *Manual* to discuss problems such as the excess of advertising used in marketing, the advantages and disadvantages of intermediaries and the influence of the cost of marketing on the country's economy. The existence of marketing methods is a fact which must be taken into consideration, but their degree of development and the extent to which they can operate at a reasonable cost, are not problems for the project-maker, who must fit each analysis to its specific case. Thus it may be that in one country the co-operative system of production and consumption is highly developed, setting its peculiar seal on the whole market, whilst in others it barely exists. In the same way, if certain state organizations are responsible for the distribution and marketing of some products, specific marketing characteristics will result, and they must be considered as such in the market study.

The importance attributed to the study of marketing will vary with the type of product. In basic development projects, marketing is not a decisive factor; if the remaining aspects of the project are favourable, it is usually possible to find an adequate solution to any distribution problems which may arise. In any case, it is advisable to present these problems and their solution in an explicit form. In other words, if the project has no marketing problems, this must be stated; if it has, they must be detailed, and an explanation given of the measures necessary for their solution.

Many problems may be revealed by the marketing study. At times, for instance, the main distribution channels are controlled by one single enterprise, whether for financial, transport, or other reasons. It is not uncommon for the sale of scarce goods to be conditional upon the purchase of more abundant items, or those which are difficult to sell. As a result, the unsatisfied demand for a product in short supply creates an artificial market for a relatively abundant product whose sale has been linked to that of the scarce product. The distribution of certain goods or services may also involve technical requirements, which must be shown clearly, so that the manner in which they are satisfied at present, and will be in the future, may be examined. This type of requirement may include repair services, or supply of spares in the case of durable consumer goods and equipment in general; technical advice on the correct use of the product; cold storage in warehouses and transport elements; distribution grids for electric power, preventative maintenance, etc. If these requirements are inadequately covered, they may constitute a notable deterrent to demand, and it will be advisable to ensure that they receive adequate attention.

(g) *Competitive goods or services*

Almost any goods may be replaced by others as a result of changes in relative prices, quality, customer preference, ease of access and other causes. The most important is probably the price relationship, whose influence may be estimated on the basis of the price elasticity of the goods, as will be explained later.[13]

Technical innovations are often an important cause of substitution, and their effects may take two courses: improvement of production methods permitting the manu-

[10] For example, replacement of natural by synthetic fibres or substitution among synthetic fibres themselves.

[11] The classification based on the use of the goods or services coincides with that of the type of consumer.

[12] It has also been defined as the process which includes all commercial activities required to transfer the ownership of the goods or services and to attend to their physical distribution.

[13] Section IV of this chapter.

facture of the same product at lower prices, or the introduction of new products to replace those at present in use. The authors of a project should take into account any such probable innovations, although it is naturally impossible to forecast all possibilities for the project's entire useful life. Technical substitution possibilities may considerably affect the market for production goods; for instance, certain types of buildings may be constructed alternatively in reinforced concrete, steel, wood, etc. Relative unit prices, availabilities, ease of operation and handling, general costs, insurance costs of the finished building and other factors may turn the scale in favour of one or another product, finally affecting the demand for them. These causes of variation in relative demand may not be completely demonstrated in a simple comparison of historical series of consumption and income, even though relative prices are taken into account, since the availability of certain materials may be the decisive factor in determining their preference. Careful research into local supply conditions will at least allow some estimate to be made of this aspect.

#### (h) *Economic policy*

The obtaining of an adequate knowledge of the market may call for a separate analysis of the relative influence of factors such as exchange control, rationing of the product, exchange rates, price fixing, subsidies, taxes and others which have their origin in political decisions. Data obtained on this subject will be useful in appreciating the influence which the maintenance or variation of economic policies will have on the project. Such evaluations will help to establish a plausible hypothesis for the purpose of projecting future demand or estimating existing demand.

### 3. *Techniques for compiling data*

Techniques of varying degrees of complexity have been developed for compiling the data referred to above; a brief informative review will be made of these. The subject cannot be discussed at length, both because of its specialized nature and because, if the project is large, and detailed research is indispensable, the services of consultants will have to be employed. The authors of the project, however, should have some general knowledge of what can be achieved by these research techniques, and also of their limitations. This will enable them to define objectives, as well as to control and to judge the results of the research. Marketing alone, for instance, covers a wide field of activities, and its study may be undertaken in many different ways; the authors of the project must therefore be in a position to stipulate precisely what they require from the study.

The technique of compiling data may be summarized under four headings: (*a*) preliminary research; (*b*) planning of the final research; (*c*) accumulation of data; (*d*) statistical sampling.

#### (a) *Preliminary research and analysis*

The first objective is a clear definition of the data required. This definition cannot always be studied in an office, and it is often useful to carry out prior, somewhat unsystematic, research. An informal survey of various sources of information may provide a general idea of the product's market problem, and offer key points which must be studied in the different specialized publications and at their sources; retail shops, wholesale distributors, sales agents, advertising agencies, etc. The object of this initial exploration is to establish working hypotheses for systematic research, and to define the points which merit deeper knowledge. It is not always necessary to make a complete investigation of all the points, mentioned earlier. The preliminary exploration and the planner's own judgement must in each case indicate the lines of research, the points to be investigated, and the amount of the funds which can justifiably be allocated to this part of the study.[14]

#### (b) *Planning of the final research*

Once the objects of the research have been clearly defined, the work of compilation must be systematized. A plan must be made of the types and sources of data required in the study; the forms to be used must be prepared; the sample to be followed must be defined; working teams must be organized, and the cost of the study and personnel requirements must be determined. Undoubtedly, the most important part of this plan is the determination of types and sources of information to be used, and the system of sampling.

#### (c) *Accumulation of data*

Sources of the data may be primary or secondary. Primary sources are consumers, sellers, purchasers, the files of enterprises—if these are long-established—and others. These sources may be explored by sampling, observation or experiment. Secondary sources are specialized publications, official statistics, and studies made by private, public or similar institutions.

The observation method consists in accumulating data through visual examination, and taking note of the phenomena under study. For instance, an enterprise which made land mines in an Asian country during the war sought by observation a new use for its equipment. They began, by examining the types of domestic utensils most commonly found in typical homes in different towns, and an analysis of the results led to a decision on the articles which could advantageously be produced.[15] The observation method has the advantage of minimizing the influence of the subjective inclinations of both the researcher and the informant, but it cannot always be used.

The experimental method consists in conducting tests to demonstrate the market reaction to the variables under examination and is somewhat similar to laboratory work —it is an experiment on a restricted market. Thus, in order to test customer reaction to certain selling methods, a sales outlet may be set up in any locality which may be considered as representative of the whole area to be served. On the basis of the experience obtained, a decision may be taken to widen the area of distribution. Similarly, if required on consumer reaction to a new type of food, or to a new preserving method (frozen fish, for example), the investigation may be started in a typical town, and con-

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[14] The inclusion of voluminous domestic and international statistics with the sole object of increasing the size of the study is totally unjustified. Nevertheless, projects are often encountered where indiscriminate statistical data is introduced to replace a true analysis of marketing and demand, which has in fact never been made.

[15] Stanford Research Institute, *Manual of Industrial Development, with Special Application to Latin America,* Foreign Operations Administration, Washington, October 1954.

clusions deduced therefrom regarding operation on a wider scale.

Surveys are the most extensive method of obtaining data. They are normally classified under three headings: facts, opinion and interpretation. The first registers only concrete facts: What type of soap do you use? Do you use washing or floor-polishing machines? Opinion surveys seek to establish the point of view on a definite subject: Which of these containers do you prefer? Finally, in interpretation surveys, the question would be: Why do you use this type of soap? Although doubts are often expressed regarding the advantages of interpretation surveys, they continue to be used to a great extent.

The preparation of forms for obtaining data from primary sources involves questions such as the advantages of queries made in writing, through the post, by telephone or by personal visit, as also the format which should be used, the order of the questions, their length and method of presentation, and in fact the pros and cons of all aspects of this matter which may affect the success of the research.

(d) *Statistical sampling.*

Some of the foregoing data may refer at times to a relatively small number of cases, such as, for instance, enterprises which use sulphuric acid in the manufacturing process. In other cases, the data refers to a very large number of individuals; this is generally true for consumer goods or services. The data must then be obtained by means of statistical sampling. The sampling principle is as follows: if a group of cases is examined (called "the universe"), of which certain characteristics, are to be determined, it is accepted that by taking an adequate number of samples, and selecting the components in a certain manner, their characteristics, will reflect those of the universe. Consequently, the basic task of good sampling is the determination of the minimum number of examples required to ensure the effectiveness of the sample, and the adoption of the most suitable criterion when selecting the sample's elements, so that it will be truly representative. Many studies have been made of both problems, and form a part of the specialized technique of marketing studies.

## III. Fundamental theoretical premises in the analysis of demand

The theoretical premises refer essentially to the demand function and to the quantitative relationships deriving from the concept of elasticity of demand. For the benefit of readers who are not familiar with these subjects, an explanation will be given here, although with a warning that the analysis of demand requires a much more complex elaboration than that contained in these pages.

### 1. *The demand curve and its variations*

It is well known that supply and demand determine the price of any goods or services. The concept of demand is more complicated than would appear at first sight, and for its complete understanding, a distinction must be made between the quantity of demand and the true demand.

The "quantity of demand" is that which consumers or users acquire at a certain price at a given moment. The "demand function"—or simply "demand"—is the relationship which exists between a series of the quantity of demand and a series of the corresponding prices.

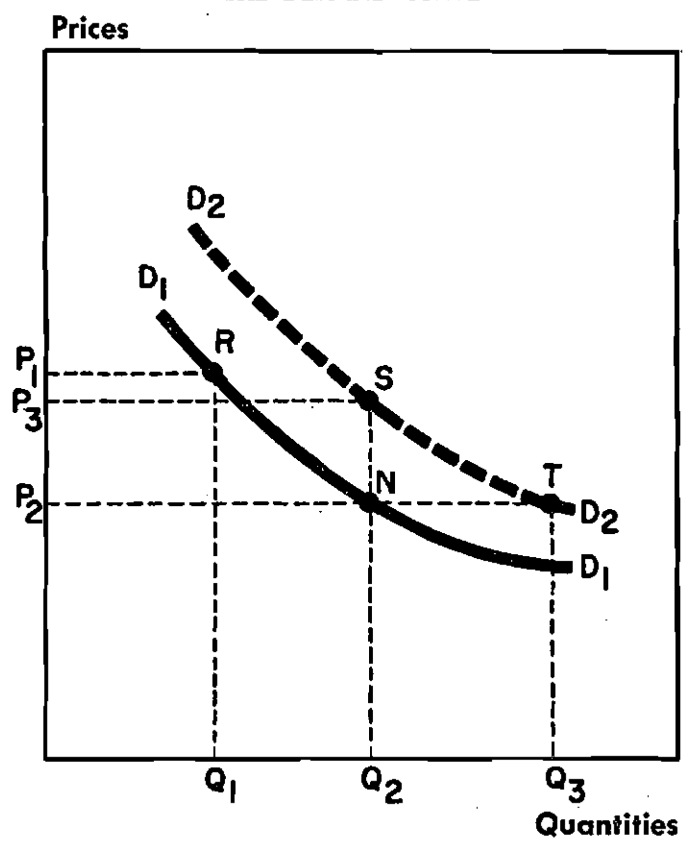
The normal practice is to present the demand function graphically, with the quantity consumed as the abscissae and the prices as the ordinates. The higher the prices of a product, the smaller is the quantity of demand. The curve representing the relationship of quantities to prices falls from left to right (see figure II).

Considering the demand curve $D_1 — D_1$, it is seen that at the point *R* there is a consumption $Q_1$ at a price $P_1$. If the price falls to $P_2$ the quantity of demand will be $Q_2$, which is greater than $Q_1$. ($P_2 — Q_2$) is the point *N*, which lies on the same curve of the demand function as point *R*. But, if for the same price $P_2$, there is a demand $Q_3$ then the plot of ($P_2 — Q_3$) is at point *T*, on a different demand curve $D_2 — D_2$. There would also have been a change in demand if the same quantity $Q_2$ were purchased by the consumers at a price $P_3$, corresponding to the point *S* of the demand curve $D_2 — D_2$, instead of at a price $P_2$ (point *N* of $D_1 — D_1$).

Displacements such as that of the point *R* to the point *N* on the same demand curve $D_1 — D_1$ are not changes in demand, but in supply. If there is a movement from *R* to *N*, it means that prices have fallen from $P_1$ to $P_2$ because of a greater supply, but if the movement is from *N* to *R*, then the prices have increased in face of a reduced supply. On the other hand, displacements from a point such as *N* to one such as *S* indicate that, at the same level of supply $Q_2$, the consumers will pay more. In this case,

**FIGURE II**

THE DEMAND CURVE



there has been a change of demand represented by the displacement of the demand curve from $D_1 - D_1$ to $D_2 - D_2$. The changes in demand therefore mean that, for the same supply level on the market, the consumers are willing to pay more or less than before, depending upon the direction of the displacement. If it is the level of supply which varies, this only implies a concomitant change in prices, within the same function or curve of demand.

The factors which make the demand curve move "upwards" or "downwards" from a given position are specially related to the level and distribution of income.

As regards the change in the level of income—which is the aspect which will principally be dealt with here—the general premise is that consumers will be willing to pay a higher price when their income level rises, or vice versa. If, in addition to a change in the level of income, there is also a variation in the distribution, there will not only be a displacement of the demand curve, but also a change in its form.

Changes in the demand curve may also occur because of movements of the geographical distribution of the population (for example, urbanization, or concentration in the cities); changes in the spending or preference of the consumers; technical innovations which introduce substitute goods or services, and other factors. In practice, any analysis of demand should take into account all these possible influences, but it is easy to see that there are considerable theoretical and practical limitations. In any case, the possible margin of error should be remembered if they are not taken into account quantitatively, and data concerning them will at least permit a general appreciation of their influence.

To sum up, demand curves such as $D_1 - D_1$ and $D_2 - D_2$ represent the relation between the quantity of demand and prices, assuming the remaining forces acting on the demand to be constant, the principal ones being those connected with income. This observation is important when working with series of historical values, since they reflect also the influence which other factors exercise simultaneously on the volume of demand. If curves are plotted of the historical series, they will not follow $(D_1 - D_1)$ or $(D_2 - D_2)$, but will show the influence of all factors affecting the demand during the historical period under review.

The relation between quantities consumed and the various levels of income can also be shown graphically. If the abscissae show the *per capita* income series and the ordinates those of *per capita* consumption, the resulting curve will indicate the volume of consumer demand at the different income levels. The income-demand curve rises from left to right, and takes a form similar to that shown in figure III.

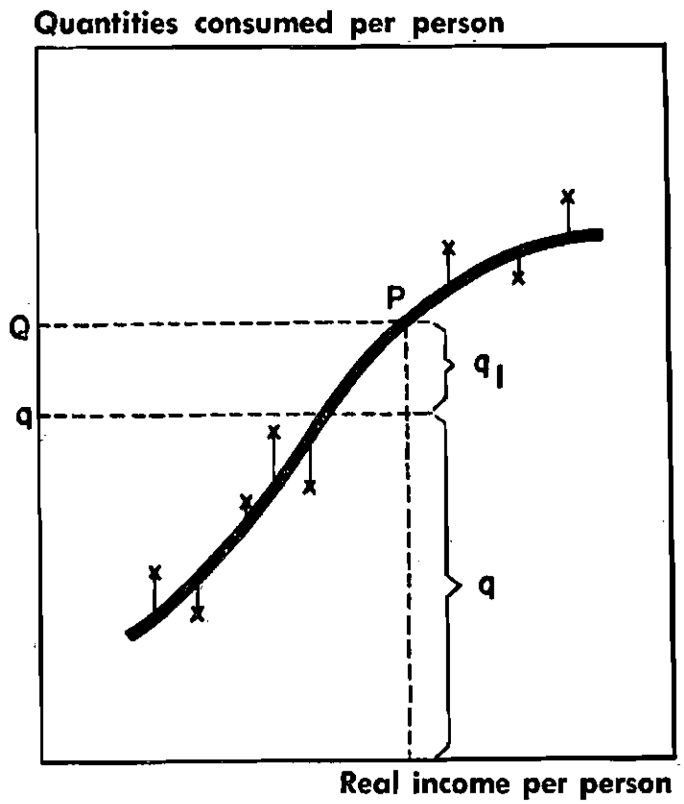
The same observation in relation to the other variables which affect demand must be made regarding the income-demand curve. The graphs obtained from historical series of the quantity of demand and income will show not only the influence of the income level but also of prices and other variables which have operated during the period examined.

### 2. *The elasticity concept*

The relation between changes in the quantity of demand and those of prices and income is shown by the form of the graphs given above, and its quantitative expression is facilitated by use of the concept of elasticity.

FIGURE III

CHANGES IN DEMAND AS RELATED TO INCOME




(a) *Mathematical definition*

First, the concept will be defined in its precise form, and later explanations will be given of its looser present day usage. Assuming that there is a relative change in one variable, while the other remains constant, the elasticity of demand to income or to prices is defined as follows:

$$\text{elasticity} = \frac{\text{relative change in the quantity of demand}}{\text{relative change of income or price}}$$

If $q = f(p)$ is the equation of demand as a function of price, that is, of the curve $(D_1 - D_1)$ in figure II, the elasticity is a point on the curve which can be defined mathematically as:

(1)
$$e = \frac{dq}{dp} \cdot \frac{p}{q} = \frac{\frac{dp}{q}}{\frac{dp}{p}}$$

Thus, according to the mathematical expression of the concept, the relative changes are infinitesimal.

For an equation $Q = F(y)$ of income, the same type of definition may be used, except that the coefficient of elasticity will generally be negative in the case of prices and positive for income.

Except in very special cases, elasticity will be variable throughout the curve, but in the analysis of demand the constancy of the coefficients of elasticity is often assumed, and it is accepted that the points on the curve will be connected by equations of the type:

$$(2) \qquad q = KP^{e}$$

$$(3) \qquad Q = KY^{E}$$

depending upon whether they refer to prices or income. The magnitudes "*e*" and "*E*" represent the respective coefficients of elasticity, and are assumed to be constant.

The foregoing assumptions permit the calculation of the elasticity coefficient in a logarithmic curve, in which equation (3) becomes a straight line whose slope is the coefficient of constant elasticity.[16] If a series for incomes and for price indices is available on one hand, and one for quantity of demand on the other, logarithmic values may be taken and plotted on a graph of quantity of demand-price or quantity of demand-income.[17] By means of a straight median line between these points, the respective coefficients of elasticity can be obtained. The degree of correlation in the median will indicate the validity of the assumption of constancy of the elasticity. If this is not constant, the median line on a logarithmic graph will not be straight, and the coefficient of elasticity will be given by the angle of the tangent to the curve at any point.

The simultaneous mathematical expression of the influence of changes of price and income will be:

$$(7) \qquad Q = K.P^{e}.Y^{E}$$

in which *Q* is the quantity of demand, *P* the price index, *Y* the *per capita* income, *e* the coefficient of price-elasticity, and *E* the coefficient of income-elasticity, assuming both coefficients to be constant.[18] If, in the equation (7), the income or prices are assumed to be constant, there is an automatic return to equations such as (2) or (3). As for these two, equation (7) is only valid to the degree in which observed values approximate to it, that is to say, to the degree to which a sound statistical relationship can be observed. Applying logarithms to equation (7), it becomes:

$$(8) \qquad \log Q = \log K + e.\log P + E.\log Y$$

which is a straight line equation in a system of 3 coordinates known as a regression plane.

(b) *Usual form of expressing elasticity*

Although the changes to which the strict definition of elasticity refers are infinitesimal, in practice, the concept is often applied to small definite changes in quantity of demand and income or prices, without destroying the functional validity of the coefficient. Relatively small changes are understood to mean figures of the order of 3 or 4 per cent, and for these cases the following definition applicable:

$$(9) \quad \text{Elasticity} = \frac{\text{percentage change in the quantity of demand}}{\text{percentage change of income or price}}$$

It must be emphasized that the above expression is applicable only when the percentages are truly small. The following examples make the difference clear. Suppose that observed values are available for quantity of demand and for income during two periods *1* and *2*, according to the following table, in which logarithmic values have also been inserted and prices are assumed to have remained constant.[19]

| *Period* | *Quantity of demand* *Q* | *Per capita income* *Y* | *log Q* | *log Y* |
|---|---|---|---|---|
| 1 | 100 | 100 | 2.0000 | 2.0000 |
| 2 | 200 | 300 | 2.3010 | 4.4771 |

The percentage change in the quantity of demand was 100 and of income 200. In accordance with equation (9), the coefficient would be $\frac{100}{200}$, or 0.5, whilst the application of the logarithmic formulae give a value of 0.63 for the same coefficient.[20]

It may be seen that the elasticity as calculated from the logarithmic equation is more than 20 per cent higher than that calculated from percentages. This is the error usually made when comparing values which are widely separated in terms of time, when the percentage variations have been considerable. If these variations had been, for instance, 2 per cent of the quantity and 4 per cent of the income (the type of variation which may arise from one year to another), the coefficient would be 0.5 according to the direct percentage relationship, and 0.506 according to the logarithmic; that is, almost equal. When long-term projections of demand are made, or when there are considerable percentage variations, it is advisable to remember this possibility of error.

[16] Applying logarithms to equation (3) for instance, then: (4) log Q = log K + E. log Y, and differentiating (4):

$$(5) \qquad \frac{dQ}{Q} = E\frac{dY}{Y}$$

or

$$(6) \qquad E = \frac{\frac{dQ}{Q}}{\frac{dY}{Y}}$$

In equation (6), E corresponds precisely to the definition of elasticity; (in this specific case, to income, but it is already known that the expression would be analogous for prices).

[17] Relative prices are generally used, and income *per capita.*

[18] The sign of *e* and *E* may be either positive or negative.

[19] It may also be assumed that the price-elasticity is so low that even if there had not been constant prices between periods *1* and *2* the variations of demand due to price changes would have been of little importance.

[20] In fact, in accordance with that equation:

$$\log Q_1 = \log K + E.\ \log Y_1$$
$$\log Q_2 = \log K + E.\ \log Y_2$$

and combining the equations will give:

$$(10) \qquad E = \frac{\log Q_2 - \log Q_1}{\log Y_2 - \log Y_1}$$

inserting the numerical values of the table:

$$E = \frac{0.3010}{0.4771} = 0.63$$

### 1. *General concepts*

The object of applying theoretical premises to practical data is to demonstrate the reaction produced by a change in prices or income on the volume of demand for any goods or services. The analysis of the data, using the elasticity concepts, will permit an estimate of the true volume of demand at any given moment, since this is not necessarily the same as the volume of transactions, if there has not been free play of the variables affecting demand. In other words, such an analysis may help to ascertain a present unsatisfied demand and to estimate its magnitude.

Care must be taken in applying the coefficients of elasticity not to lose sight of the possible effect on the statistical series of local factors or circumstances which have had a temporary influence on the market, and which are overlooked in a general pattern such as is given here.

The algebraic correlation, and the somewhat complicated statistical calculations, may often result in the over estimation of the analytical possibilities of the elasticity coefficients and the validity of the conclusions derived from them. The quality of the basic statistics, the possible errors in estimating the constants mentioned earlier, and the impossibility of completely separating the effect of the other variables must be taken into account. These limitations mean that the accuracy suggested by the calculation will be only apparent, and that the results should be qualified according to the circumstances of each case. At the same time, these limitations should not lead to an underestimation of the analytical possibilities of the theoretical premises. As always, careful consideration and sound judgement will be the factors which govern a good decision.

The analysis of demand for consumer, intermediate and capital goods must be approached in different ways. The quantity of demand for consumer goods will be directly related to income and prices, and can be analysed by using the respective elasticity coefficients. On the other hand, the quantity of demand for intermediate and capital goods, although affected to some extent by the level and distribution of income, and by relative prices, also depends very largely on structural changes in the economy.

First, the application of the elasticity coefficients to the current demand for consumer goods will be explained, and later, the additional factors which must be taken into account in the analysis of demand for intermediate and capital goods. Income elasticity has been separated from price-elasticity only for the purposes of the argument, but naturally both will be used in the analysis.

### 2. *Price-elasticity of demand*

#### (a) *Magnitude of the coefficient.*

The elasticity coefficient is an abstract number, and is generally negative, since the volume of purchases tends to decrease as prices rise, and to increase as they fall. For example, assuming the price-elasticity is —2, if the price of the article in question changes by 1 per cent, the amount purchased would change by 2 per cent, but in the opposite direction. If the percentages of prices changes are accompanied by equal percentages of changes in the volume of purchases, the coefficient is 1, and the elasticity is said to be unity. If the quotient is less than unity, the demand is said to be inelastic to price, and if greater, elastic to price.

The magnitude of the price-elasticity coefficient is largely determined by the degree of indispensability of the goods or services; the less indispensable they are, the lower the elasticity coefficient. The elasticity coefficient of demand for bread is thus less in most countries of low or medium income, and is much lower than unity. The so-called protective foods, which are generally less indispensable than the energy-building foods, in most cases show a relatively high coefficient of price elasticity when compared to other foods. The same type of food may show considerable differences in the elasticity coefficient between countries or groups of consumers with different income levels. These differences arise from the fact that the degree of indispensability varies as the income of the consumers rises.

The magnitude of the coefficient also depends on the possibility of finding another article which could be used in substitution for the item under analysis. For instance, the price-elasticity coefficient of most alcoholic beverages is high, reflecting the fact that if the price of any one of these beverages is increased, consumers can easily find a similar substitute; for this reason, any slight price increase tends to produce a large reduction in the demand for this type of beverage.

#### (b) *Measurement of the coefficient*

The data needed to measure the coefficient of price-elasticity are those relating to prices and consumption. For the former, a series of retail selling prices is required for a given market for a period of years or months, depending on the study. For projects, annual average prices are generally required.[21] The prices used in the calculation must be deflated, either by prices of the substitute items, the cost-of-living index or the general price index.

The consumption figures required are those of the true consumption by the population. As far as possible figures for apparent consumption should be avoided. Since total consumption of any goods or services is a function of the number of consumers, *per capita* consumption must be used. Normally, the correction is made by dividing by the total population of the country, or the total consumer population, which may be less. If, for instance, minors of less than ten years old are assumed not to be consumers, the demand should be in terms of *per capita* consumption for persons over that age. These considerations can be very important, since during the period under review there may be wide changes in the birth rate or in the infant mortality rate.

Once the price and consumption series are obtained, they may be shown on a logarithmic graph, and a median line established for the scatter diagram. As has been explained earlier, the angle of the tangent to this curve measures the coefficient of price-elasticity, and if the median is a straight line, then the elasticity is constant.

It must be remembered that measurement based on historical series has only a relative value, since the demand will also have been affected by changes in the level of income and other factors. It is seldom easy to obtain series of true values, free of the effect of income changes, for

[21] An analysis of average prices for periods of less than one one year introduces an additional problem of seasonal variations, which is of no interest in this case.

quantity of demand and prices. Valuable information may be obtained at times by measuring the changes in demand occurring immediately after changes in other prices. An example of this is the consumer reaction to an increase in the rates for electricity or gas.[22]

(c) *Price-elasticity in market studies*

Knowledge of the price elasticity coefficient of demand for any goods or services permits an approximate appreciation of variations in the quantity of demand, and consequently in the value of sales, which would result from a change in the price of the goods in question.

Assuming, for example, that demand is 2 shirts per man per year, at a price of 100 pesos each, and that the price-elasticity for shirts is 1.5. If the price rises to 101 pesos (1 per cent), the consumption per man would fall by 2 per cent to 1.97. In an area where 10 000 men live, the volume of sales would decline from 2 million pesos per year (20 000 at 100 pesos) in the following manner:

Former value: $10\,000 \times 2.00 \times 100 = 2\,000\,000$ pesos
Present value: $10\,000 \times 1.97 \times 101 = 1\,989\,700$ pesos

In other words, if the consumer population remains constant, the total value of sales will decrease even though unit prices have increased.

It should also be remembered that the price elasticity of demand for an individual producer differs from that for a group of producers. By means of a small price reduction, to below the level of his competitors, an individual producer can sometimes achieve a high proportional increase in sales. If, however, all producers reduce their prices for a certain article, it is most probable that there will be no great increase in the total demand for the item, unless the price-elasticity is high.[23]

### 3. *Income-elasticity of demand*

(a) *Magnitude of the coefficient*

The coefficient of income-elasticity of demand is almost invariably positive, since both income and the quantity of demand change in the same direction. The *per capita* consumption of any goods or services may normally be expected to rise with increase of income, except in the case of low quality goods, the consumption of which will decline with increase of income.[24] The coefficient may be greater, the same as, or less than unity. If it is greater, the demand is said to be elastic to income; if it is unity, this is unit elasticity, and if less, then the demand is inelastic to income. The curve of the graph is such that, from a certain point, the slope decreases in proportion to the increase in income. This is because the income-elasticity of demand for any goods normally decreases after certain levels. In practice, the income-elasticity of demand is measured from only one part of the curve, and it is generally assumed to be constant within prudent limits.

(b) *Measurement of the coefficient*

There are various prudent methods of measuring the coefficient of income-elasticity, each producing different values. One uses historical series of *per capita* income and consumption, and proceeds in the same manner as for price-elasticity. This type of measurement implies assumption of constant prices during the period under review, or that any changes would have very little effect. As an alternative, periods can be selected during which there have been changes in income, but not in prices. There are occasions where historical figures do not show any increase in consumption, even though income increased during the same period and low-quality goods are excluded. If there was no possibility of expanding the supply of these goods during the observed period, shortages may well have been responsible. Similar situations may be seen during period of rationing caused by inflation, war, or in many Latin American countries, by restricted supply resulting from balance-of-payments difficulties. Care must therefore be taken that errors do not arise from calculating the income-elasticity coefficients of demand without due analysis of the supply situation during the period examined, especially when the economic policy has been such that the short supply has not been allowed to affect prices.

One method of evading the influence of supply irregularities on the article being studied is to measure the coefficient on the basis of consumer budgets. For this method, a survey is made at various income levels amongst consumer family groups which represent the "universe".

The families are grouped into the various categories of *per capita* income, and the *per capita* quantities consumed are compared with the corresponding *per capita* incomes. In this way a demand-income correlation is obtained which is not influenced by changes in the supply position or in relative prices. The resulting coefficient of income-elasticity of demand may be said to be true, since changes in relative prices, in customer tastes, and other factors which affect historical series, have been eliminated. Sufficient data are not always available to enable this method to be used for calculating the income elasticity coefficient, and it is necessary to fall back on historical series.

Finally, there is a third coefficient of income-elasticity based on *per capita* consumption and income in a number of countries. This coefficient, which may be called "international", has a much more limited value in the study of a specific project, but may supply reference information where satisfactory local statistics are lacking.

The simple definition of income-elasticity demonstrates its importance in the market study of a specific article or service. For instance, if sufficient statistical information is available on the distribution of income and consumption of the population by income levels, it is possible to estimate the effect which a change in distribution had or could have on the demand. It may also be used as a criterion for

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[22] See Cristobal Lara Beautell, *La Industria de Energía Eléctrica* in the series *Estructura Económica y Social de México, Fondo de Cultura Económico,* Mexico, 1953.

[23] This difference also has a certain importance on a national scale. For example, although it is true that the price-elasticity of demand for coffee is low on the whole, this is not the case for an individual producer or for a specific exporter country. It this country is a small supplier on the world market, and if it has a very large harvest, it would probably be able to sell this harvest much more easily by reducing prices below the world market level, without causing any great reduction in the price of coffee from all sources. On the other hand, if the country in question were a large producer (Brazil for instance), the reduction would lead to a decrease in the prices for all producers.

[24] Typical cases are foodstuffs consumed by the very low income groups, where the demand decreases with increase of income in these groups; a notable example is maize in Latin America. The demand falls with increase of income, and wheat is substituted for maize—bread is eaten instead of "tortillas".

quantifying the potential demand, since it permits an estimation of what consumption should be under certain income conditions, assuming certain hypotheses regarding prices and other factors.

### 4. *Other correlations*

When examining the effects of changes in prices and income on demand, the following equation can be used:

$$\log Q = \log K + e. \log P + E. \log Y$$

where $Q$ is the *per capita* quantity of demand, $P$ the relative price index, $e$ the price-elasticity of demand, $Y$ the *per capita* income, $E$ the income elasticity of demand, and $K$ a constant.

The validity of the assumption that coefficients $e$ and $E$ are constant will depend upon the degree of correlation in a statistical analysis; this problem is outside the scope of the present discussion. Graphical presentation is difficult, since it requires three co-ordinates.

An alternative procedure is as follows: on a graph whose abscissa represents *per capita* income, and ordinate the *per capita* consumption, points are inserted for each pair of values observed in the historical series (see again figure III.) A scatter diagram is thus obtained from which a median may be drawn in accordance with normal procedure. The scatter points will only exceptionally fall on the median, and their distance from either side of the curve will be variable. The extent of these variations will be greater in direct proportion to the lack of information as to whether the changes in *per capita* consumption are due to changes in income. If changes in income were the only cause of variation in the quantity consumed, all the points would fall directly on the curve. Since this never happens, it is said that the distances of the points, or the differences, are not "explained" by changes in income, and they are called the "unexplained balance".

The numerical magnitude of this unexplained balance in each one of the observations is determined by measuring the difference between the true *per capita* consumption at a certain income level and the consumption which should correspond to that level according to the curve. Thus, referring to figure III, in income level $y$ the consumption level is seen to be $q$, whereas according to the curve the consumption should be $q$ plus $q^1$. The difference, or unexplained balance is therefore $q^1$. If the unexplained balances for each income level are known, they may be used as ordinates in a further graph in which the abscissa will be the price of the article (deflated by the general price index or by the prices of the nearest substitute). In this way a new scatter diagram and a new curve are obtained, which will permit the measurement of changes in demand attributable to the price effect.

### 5. *Demand for intermediate goods*

Intermediate goods or services are those used as inputs in the production of other goods or services. Although also affected by variations in income, the demand for this type of article would be, in direct terms, a function of the demand for goods in whose production it is employed, and of the proportion to which it enters into such production.

When the goods or services under study have many applications, knowledge of the entire system of industrial relationships involved is needed to determine demand. It is most improbable that information of this type will be available, and hence the study will have to be limited to the principal sectors or activities which use the goods or services. So-called sources and uses studies, made on the basis of statistical compilations and surveys establish the technical and economic relationships, which, in important sectors, govern the demand for the intermediate goods or services under review and their principal sources of supply.

When the intermediate product is related to only one, or to few consumer goods, an estimation may first be made of the demand for these goods, calculating the demand for the intermediate product on the basis of technical relationship. There are also the effects of possible substitution, which may arise as a result of probable changes in the relative prices of input items, and technical innovations which could cause changes in the input coefficients per unit of product.

There may be a high direct correlation between income and the demand for intermediate goods or services. This is obvious when there is preferential use for the intermediate product in only one consumer article (pulp for paper, flour for bread, fish for preserving, etc.). It has also appeared when, amongst other cases, the use of the intermediate product is very widespread (electric power, transport, etc.).

As regards the influence of price, there are no notable differences between the analysis of the demand for an intermediate product and that for a consumer item, but in the latter case there is more possibility of substitution, since there is no technical compulsion to work with certain definite input items.

### 6. *Demand for capital goods*

From the project point of view, a study of the demand for specific capital goods—electric motors, spades, wheelbarrows, machine tools, lorries, etc.—involves the same type of problems as for intermediate goods.[25]

It is therefore necessary to make a sources and uses study of the capital goods concerned, to establish the corresponding technical relationships and substitution possibilities for other capital goods, and to examine the incidence of structural changes in the economy on the demand for the particular capital goods. The demand for capital goods will be influenced by their durability and by the possible substitution of human or animal labour. The former aspect is related to depreciation, and the latter to mechanization.

The technical relationship between production and input of capital goods cannot be determined by simply comparing production and purchasing statistics in any one

[25] Economists approach the problem of the demand for capital goods by establishing in the first place that such demand depends on that for final consumer goods, and for intermediate products required to produce the consumer goods. Since the production of capital goods requires in turn the use of other capital goods, it may be said that the demand for these is finally related to that for all other conceivable goods and services. From the theoretical relationship between the growth of general demand and that for capital goods has been derived what books on economics describe as the accelerator theory. The accelerator is the increase in the demand for capital goods resulting from an increased demand for goods of all types. However, when specific capital goods are involved, the changes in demand must be explained—as for intermediate goods—by changes in the economic activity of the user sector.

enterprise or group of enterprises. A more careful analysis is necessary, not only because of possible technical innovations in the productive process, but also possible variations in the intensity of use of installed capacity during the period (one or more shifts). A considerable difference is seen here from intermediate goods, since for these, the relation between quantity produced and input of any goods can only vary as a result of technical changes, and if production is increased, the input of intermediate goods must increase in proportion. In the case of capital goods, the existence of idle installed capacity permits additional output without increase of demand. On the other hand, it must not be forgotten that more intensive use of capital goods also leads to more rapid wear.

Mechanization involves a process of substitution between productive resources, and will be affected by relative prices, by customer preference, and by factors such as the technico-cultural level, credit policy, and other types of stimulus.

On a more general plane, the problem of mechanization may be related to the targets of a development programme which involves the liberation or absorption of a specific labour force, or both. Similar considerations may arise in the case of electrification. This type of policy may compel changes from one form of energy to another, and this in turn will affect the demand for certain capital goods. Electrification of rural areas, for instance, may lead to an increase in the demand for electric motors and other mechanization equipment.

In short, the analysis of demand for capital goods will require a sources and uses study similar to that for intermediate goods, but with certain variations deriving from the technical relationship between production and the capital goods needed to achieve it, as well as the possible substitution of one form of power for another. Finally, a most important factor in the demand for capital goods will be the replacement rate for those which have already completed their useful life, either because of wear or economic obsolescence.

### 7. *Conclusions of the analysis*

In the original scheme, the main objectives of the analysis of current demand in a project could be summarized as: (*a*) to find out the volume of the goods or services involved in the project, which the consumers were willing to acquire, and (*b*) to determine, with the aid of the empirical data already mentioned, if the installation of additional productive capacity for such goods or services is truly justified.

As regards the first point, it has been seen that very elaborate study is seldom necessary to decide if a certain demand is unsatisfied; it is sufficient to talk to a few suppliers and traders in that line, or with a few habitual consumers. The analysis therefore resolves itself into an estimation of the volume of the demand. When the market situation is not so clear, a comparison of profits, prices, consumption and volume of orders from middlemen at the time of the study, with figures for previous years, may facilitate a fairly close appreciation of the current state of the market. In cases where this direct comparison is insufficient, an analysis based on the concepts of price and income-elasticity may be most useful. Because of the quantitative relationships explained earlier, it may be determined whether the figures for consumption and prices conform at the moment to those which would result from the equations; it will thus be possible to ascertain whether an unsatisfied demand exists and also to quantify it.

For instance, if the development of income as from a specific date is known, and the income-elasticity of a particular item, a first calculation can be made of what current consumption should be, assuming constant prices. The result of this calculation is compared to the true consumption, and then analysed to see it the difference can be explained in terms of probable changes in relative prices, given a certain amount of price elasticity. If it cannot be so explained, then there would be an abnormality. If the calculated consumption were greater than the true, there would be an unsatisfied demand at present prices. The equation of double correlation of income and prices could also be applied here, if known, and true current consumption compared with what it ought to be according to that equation.

In some cases, the volume of the deficit may be estimated in a much simpler manner (for example, unfulfilled requests for telephone installations). In less obvious situations, the comparison between the "calculated" and true values may give valuable indications, and will at least permit an estimate of the size of the demand.

However, errors may arise through estimating the potential demand by comparing true consumption with specific ideal standards. It may be said, for instance, that if milk consumption—for a normal diet—is 180 litres *per capita* per year, and actual consumption is only 100, there is an unsatisfied demand for 80 litres *per capita* per year. As a result, the demand for milk is over-estimated, unless this product has a very high price-electricity and greater production would result in unusual cost reductions. Similar errors are often found in analyses of the market for housing services, studies of the needs for agricultural machinery, and others.

The decision to install new capacity to meet a specific unsatisfied demand involves a prior enquiry as to whether there is idle installed capacity in domestic production as a whole, for unsatisfied demand may exist even when there is sufficient installed capacity. It may be that there is a shortage of raw material; that producers have formed a cartel and are restricting the supply in order to increase profits; that there is insufficient electric power; that there are labour difficulties; or one of many other limitations. In these cases it is most useful to have all the information mentioned earlier in connexion with the collection of data, since this will permit an appreciation of whether the unsatisfied demand results from causes which may be considered transitory, or from lack of production capacity.

The comparison between the unsatisfied demand and the existing production capacity to meet it acquires special significance when the problem arises on the international level, especially in the case of agricultural and mining commodities for the production of which there is idle capacity in some countries and unsatisfied demand in others.

The market study of any such goods for a given project should consider this situation and the possible international agreements which might be negotiated as a result. On the national level, an important problem of evaluation will arise. For its solution all possible data will have to be assembled in order to ensure the best use of available resources. In the case of wheat production, for example, consideration must be given to what alternative uses can be made of the soil, manpower, agricultural machinery (or its equivalent in foreign exchange), and of the other production factors applied in domestic production.

The study of the project should be based on the maximum amount of such information in order to facilitate the evaluation. Useful documentation will often be found in studies made by United Nations specialized agencies such as the Food and Agriculture Organization (FAO) and the regional economic commissions.[26]

If the new production to be installed will replace other market suppliers, the final decision will depend essentially on prices, quality and marketing technique. It must be remembered that for a small producer, who hopes to supply a small part of the total demand, the price-elasticity coefficient may be much higher than that for the total demand. Appreciations of quality and marketing will be based on the data collected, as explained earlier. When it is intended to replace foreign suppliers, possible tariff protection or other stimuli will also be considered.

Finally, it is obvious that the justification for installing additional capacity must be based not only on present unsatisfied demand, but also on possible future development; this point will be dealt with in the next section.

[26] The problem of alternative uses and costs and the indirect effects of a project on the rest of the economy will be fully dealt with in Part Two.

## V. Projection of demand

### 1. *Need for the projection*

It is easy to understand the need to estimate future demand for the project both in terms of the quantity and prices of the goods or services to be produced. If a decision is made to install an industry, drill a mine or develop a branch of agricultural production, without making any projection, it must be assumed that for a certain number of years a specific quantity of goods or services can be sold at certain costs and prices with a profit which will permit amortization of the investment and still leave a net gain. Explicit forecasts are undoubtedly to be preferred to these implicit ones, even though the available means of preparing them may be inadequate and may not lead to a mathematically sure estimate. It cannot be over-emphasized that the appraisals or conclusions derived from projections constitute what may be termed an illustrative estimate, reached through using instruments of economic analysis and relevant data which it has been possible to compile. Such an estimate can never pretend to determine precisely what quantities must be sold, nor at what prices, in the future. Although a projection is a complicated task, that is no excuse for omitting it, as is frequently done. If it is omitted, and current prices are used for costs and income studies, the only prediction of prices which is being made is that they will remain constant during the entire useful life of the enterprise. This attitude may be justifiable, but in that case it must be explicitly stated, and full reasons given for its adoption. At times, a project may seem to be unjustified when accepting the level and relations of prices in force at the time of the study, but it may be that these prices and relations are at an abnormal level. Inversely, some projects appear attractive when using current prices, but cease to be so if these prices are seen to be artificial or transitory. Examples of such situations may be found in the violent fluctuations in the prices of coffee, tin, copper, sugar, etc., during the post-war years. All projects concerned with such commodities, studied and evaluated on the basis of those prices, would have appeared attractive and of high priority, whereas a long-term study would have led to widely different conclusions. Optimism in periods of prosperity—or inversely, a tendency to avoid new enterprises during the pessimistic period which accompanies recessions—will not be the best guide, and possibilities must be compared in accordance with an objective and calm study of the data.

The projection of volume of demand and prices is one of the problems where personal judgement must remedy the absence of other equations which would reduce the operation to routine. The price theory, and economic theory in general, do not permit the deduction of clear operational sequences for a practical approach to the problem. There are no definite standards for estimating future demand and prices, and the methods of projection used in practice have therefore varying degrees of complexity, from extrapolations of historical trends to elaborate methods of correlation. The degree of precision selected will depend upon the nature of the problem, the obtainable data, and the availability of experts in this type of work. For these reasons, the presentation of methods which follows will be essentially practical.

### 2. *Projection of demand for consumer goods and services*

Under this heading, an explanation will be given of methods of projection based on extrapolation of the trend and on knowledge of the demand-income function; in the special cases explained below, these methods may also be used to project demand for non-consumer goods and services.

#### (a) *By extrapolation of the trend*

This method consists of establishing a median between the quantities consumed over a specific number of years, and estimating future demand from the trend of this line. In more detailed studies, *per capita* consumption is used; in rough projections only total consumption is used. If the equation of the median is known, it is possible to extrapolate, and insert on the graph the points indicating demand in future years. To simplify the presentation of the graph, logarithmic values are often taken, from which curves can be reduced to straight lines. The series must be long enough to avoid exaggerated effects on the trend lines from short-term cyclic variations.[27]

From the theoretical viewpoint there are two general methods of justifiying this form of demand projection. One consists in accepting that each economic activity follows a law of growth which can be represented by an asymptotic curve with time. According to this theory, which may be accepted in the case of certain consumer goods, it is possible, by examining a sufficiently long series to verify

[27] For a more complete explanation of determination of trends, see, for example, Frederick E. Croxton and Dudley J. Cowden, *Applied General Statistics*, Prentice Hall, New York, 1948. There is a Spanish edition published by the Fondo de Cultura Económica, Mexico.

the point on the curve corresponding to demand for the article at the time under analysis. If the characteristics of the curve showing the growth of this activity from the time of its origin to maturity, and the part of the curve already past are known, it would be possible to ascertain whether the trend will be maintained during the period of projection or whether there will be a point of inflexion in the curve. If the period before the curve changes its form is sufficiently long, extrapolation of the trend would be justified.

According to the second theory, events which in the past determined the historic growth rate of production and consumption will continue to operate in the foreseeable future, and their average effect on the activity being studied will continue to be the same as that observed in the past. This theory, which could be called that of "compensated effects" argues that possible changes in the relative size of each of the factors affecting demand are compatible, since their joint or average influence will be compensatory, and hence effects will be the same as in the past.

Both the "compensated effects" and the "asymptotic growth" theories are very vulnerable, but although the method of projection of trends is subject to certain academic doubts, it continues to be used in individual projects. The extrapolation method is useful in those cases where means are lacking which would permit the use of other methods, and where there are some grounds for accepting the premise that past conditions may continue to act for a reasonable future period. The objections to the method are even more serious when considering intermediate and capital goods, as will be explained later.

(b) *By means of the coefficient of income-elasticity*

The other general procedure for determining future demand for consumer goods is based on knowledge of elasticity coefficients and on the possibility of projecting the growth or variation of income.

The method based on income-elasticity coefficients assumes that all factors affecting the volume of demand apart from income, will so operate during the projection period, that the net outcome remains constant and equal to that produced in the past. The basic difference from the projection of trends lies in the fact that it was formerly assumed that *all* factors acted in the same way as in the past, whilst now it is assumed that all factors will be self-compensating, except one. The procedure is justified when income is one of the main factors determining the volume of demand. If the demand for a product has a very low price-elasticity, the quantity consumed will be very little affected even by strong price changes. If, furthermore, this same product has a high income-elasticity, price variations will not cause any notable changes in the volume of demand, estimated purely in terms of changes in income. The method really calls for operation on the basis of available *per capita* income, but for lack of sufficient information, it is often based in practice on the national income or *per capita* gross national product. This procedure is acceptable as long as it can be assumed that there will be no changes in the taxation policy, nor in that of distribution of dividends.

With the income variable defined in this way, some method has to be adopted for its projection. This is a delicate task which involves applying the whole theory of economic development, and requires the separation and projection of all factors which decide the changes in the level and direction of investments, and in the level of employment. The problem raises questions beyond the scope of the study of a specific project, and the authors of projections must seek the aid of specialized bodies. In practice, it may be remembered that the figures for several Latin American countries for the period 1925-1953 show a certain stability in the annual growth of *per capita* product. On the basic of these data, and in the absence of better information, income may be projected by retaining the historical growth rate.

Once these basic data have been defined and determined, the projection of the volume of demand in terms of income is simple. For example, if it has been estimated that *per capita* income will increase at the rate of 3 per cent annually, and that the elasticity is 1.5, then the demand for the goods or services in question may be expected to increase at the rate of 4.5 per cent annually ($3 \times 1.5$). Assuming that the population will increase by 2 per cent annually, then the increase in total demand will be 6.5 per cent annually (4.5 per cent *per capita,* plus 2 per cent increase in population).

The projections thus obtained should be qualified by those factors whose possible effect on the market may appear from previously compiled data to be important: they include marketing problems, economic policy, technical innovations, prices and others.

The income-elasticity coefficient may be calculated—as already seen—from historical series, consumer budgets, or international comparisons. This last method is generally used only for estimates which do not call for great precision. For the other two, it is preferable to use information obtained from budget data, since this eliminates the effects of the other variables.

When total *per capita* income is used as an independent variable to project demand, taking family budgets as the elasticity coefficient, the income-demand function, by income levels, is accepted as having the same elasticity as the average national income-demand function, over the course of time. Suppose an attempt is being made to project the demand for a certain item, on the assumption that the average national *per capita* income will rise from 200 to 250 units per year. Suppose further that family survey information is available indicating that the elasticity is 1.5 between income levels of 200 and 250 monetary units *per capita.* The use of the coefficient 1.5 to project future demand implies that the future reaction of the average national consumer throughout the period of the projection will be the same as that for those groups of consumers between the levels of 200 and 250 *per capita* at a given moment. This is not necessarily the case in practice, but it may be taken as an acceptable working hypothesis.

The projection will obviously be reached more satisfactorily if information is available not only on consumer budgets at a given moment, but also on the estimated distribution of income during the projected period. In that case, the elasticity coefficients can be applied to the future levels which were obtained from previous studies of consumer budgets at those levels. Variations in distribution of national income may have heavy repercussions on the volume and nature of the demand, since for the same percentage increase in average *per capita* national income there are differing percentages of increased income in the different groups, classified by income levels.

If then, the redistribution favours the lower-income sectors, there will be a greater average *per capita* increase in these sectors than in the national average, or than in the *per capita* average of the higher-income levels, which may even decrease. If in addition to these differences in the rate of increase of income, the different degrees of elasticity by income levels are considered, the demand projection will be much more exact than that resulting from national averages only. This requires a knowledge of consumer habits at the different income levels, and the adoption of a working hypothesis as to what happens when people pass from one income level to another.[28] It is most improbable that this information will be available in under-developed countries, but special surveys could be made to obtain it, if it were considered sufficiently important.

The projection of demand may also be improved by by making the analysis by geographical areas, and considering possible future movements of the population. The elasticity coefficient must then be known for each area, and a good programming study must also be available in order to estimate future changes in the population and levels of income in the various areas.

### 3. *Projection of demand for intermediate goods*

In accordance with what has already been said, the future demand for intermediate goods and services will depend upon two basic factors: the growth of enterprises already installed which use these goods, and structural changes leading to the installation of enterprises of different natures, but which also use them. Having obtained the sources and uses information already referred to and having estimated the growth of existing enterprises, it is easy to obtain the initial component of the future demand of the goods or services in question. It is more difficult to estimate the component derived from the structural change, especially when there are no specific economic development programmes. As an alternative, a survey may be launched among entrepreneurs or governmental bodies regarding their intentions to install new productive units requiring as inputs the goods or services in question. Normally, it is incorrect to project this demand by means of extrapolations of trends or by correlation with available income. Take the case of a country which only uses sodium carbonate to make glass and soap. The historical trends of consumption of this semi-product will reflect only the joint growth of these two industries, and a projection would only consider the probable growth of the glass and soap industries and their consequent consumption of sodium carbonate; it would not indicate the effects of the possible installation of one or more new industries in the country, also employing this same material. In the case of intermediate products, the omission of possible structural changes places certain limitations on the simple extrapolation of trends, especially in countries in course of rapid development.

Similar comment may be made regarding the projection of demand for intermediate goods and services in terms of income, excepting cases where they are to be used as inputs in one other single item (pulp for paper), or for a very wide range of activities (electric power, transport). The demand for this latter type of goods or services is usually closely related to income.

[28] See remarks on emulative consumption made by James S. Duesenberry in *Income, saving, and the theory of consumer behaviour*, Harvard University Press, Cambridge, Mass., 1949.

The demand for intermediate goods or services can also be projected in terms of the development of certain sectors with which they are technically connected (for example, concrete with building). Basically, this involves the use of a simplified variant of inter-industrial relationships, which in any case requires a projection of activity in these sectors. If there is no formal development programme containing these projections, a more or less approximate estimation must be made of the growth of the sectors concerned, which in fact is the same as a projection with less rational and statistical background.

In short, the projection of demand for goods and services requires a study of sources and uses, and an estimation of future structural changes in the economy. If insufficient data were available, at least a rough estimate could be made, projecting demand by extrapolation of trends and adding a further demand component based on knowledge of new enterprise to be installed. In special cases, the projection may be made in terms of income or by extrapolation of trends.

### 4. *Projection of demand for capital goods*

Demand projection for capital goods must take into account the following basic aspects: (*a*) the replacement of capital goods at present in use, and which are nearing the end of their useful life;[29] (*b*) the expansion of installed capacity in present production lines as a function of the increase of demand for the various items;[30] (*c*) possible technical innovations in production methods;[31] and (*d*) structural changes in the economy leading to production of new items.

The basic information required to project demand for replacement includes the number of units at present in service, their age-composition, and their probable useful life. If these three points are known, replacement needs during the years of the projection can be determined.[32]

Demand capital goods, arising from installed capacity being expanded to meet future demand for the respective goods and services, may be estimated from the technical relationship between the required production volume and the capital goods needed to achieve it (e. g., number of metres of cloth which can be produced by one loom).

With regard to the third aspect, it is difficult to state precisely what type of data is required. The mechanization process, for example, may become more urgent because of increased labour costs, stimulus received from the economic policy, or new opportunities created by the electrification of certain areas. Similarly, where agricultural mechanization or electrification programmes exist, estimates can be made of the demand for capital goods resulting from them. Under this heading, the demand for capital goods must be projected in accordance with the circumstances of the case.

The effect of structural changes on the demand for capital goods may be satisfactorily estimated only where known development programmes are in process.

[29] See chapter on estimated budget, referring to depreciation and obsolescence.

[30] For example, new buses or urban transport, to carry the greater traffic.

[31] An example in this case would be the mechanization of any of the sectors.

[32] See the projection of demand for lorries in Brazil (illustrative case No. 10).

The initial plan showed the need to approach the market study in two stages. The first was to estimate the total volume of demand; the second, the part of that demand which the project could hope to satisfy, in order to determine the size of the new capacity to be installed that is, the size of the project. In the preceding section the problem has been examined in relation to present demand, and this must now be repeated in the light of projected demand. The possible influence of prices on the volume of this demand necessitates prior discussion of the problem of price projection, in order to analyse later, jointly, the relation between future quantities of demand, possible price changes and the size of the project.

### 1. *Prices in relation to demand projection*

The methods explained for demand projection start from the assumption that consumer tastes and technical production coefficients change very slowly, and that the prices of goods or services, those of the factors contributing to their production, and the ratio of input to output prices remain constant throughout the project's life. If this latter relationship should change without any compensating factor intervening, the amount of profit would change, which may in turn involve variations in the supply, in the price level of the goods in question and therefore in demand. The general price level will also affect the demand. It may happen that whilst input prices and the selling price of the product remain constant, there is a change in other prices, thereby modifying the true remuneration for the factors used to produce the goods studied. This may affect the availability of investment resources which that activity hoped to make use of in the future, again influencing successively the supply, prices, and the demand for the goods.

These theoretical premises compel acknowledgement of the influence of prices on the volume of demand, and therefore of the problem of their projection which is indispensable from the evaluation standpoint. All projects must include a budget of income and expenditure, and this involves estimating the probable effective price of both input and output factors. Therefore, although the price problem may be disregarded in the demand projection, the preparation of a budget makes it essential to have a specific stipulation of future prices of input and output factors. Thus, because of the coherence which must exist between the various parts of the project, the estimate of prices made for the income and expenditure budget must be compatible with the assumed events when quantifying the demand. In other words, the explicit prices in the budget must be the same as those implied in the demand projection.

The problem of price projection is very far from being solved, and there is no set system for its systematic treatment. For this reason, only a pragmatic treatment of this problem will be given here; the same section will cover the incidence of prices both on the total volume of demand, and also in relation to the size and evaluation of the project.

Reference must again be made to special studies of certain products (petroleum, sugar, copper, wheat, coffee, etc.) made by national or international organizations and large concerns. They will contain many valuable elements for analysing this problem.

### 2. *Practical approach*

#### (a) *The case of the entrepreneur*

The practical approach to the problem described above must be as follows: estimates of the volume of total demand should be corrected for possible price effects; this corrected demand should be compared with existing installed capacity, and the difference between the two will the amount of new production capacity which the market requires; finally, it must be decided which part of the market capacity should be met from the project being studied, thus solving the problem of the size of the project.

In order not to approach directly the problem of price projection, the plan may be simplified by considering the possible situations which may confront the entrepreneur. Size is affected by many other factors in addition to the effect of prices on demand, and consequently on the size of the project. Hence, no great precision may be necessary in the preliminary estimate of demand.

As regards the effect of prices on the evaluation, the practical approach is to calculate the income and expenditure budget assuming alternative minimum, maximum and probable prices. The margin of tolerance of profitability which the project will admit will naturally affect the entrepreneur's decision regarding its execution.

In practice, it is also often assumed that prices related to the project are constant, once they have been adequately corrected, or with due allowance for easily detected price distortions (such as high profits for habitual producers) which serve as a warning of the special caution needed in the estimation.

#### (b) *The size of the project*

The examination of the part of demand which will be met by a specific supplier is theoretically complicated, because it means determining the manner in which demand will be spread over the possible suppliers; in practice, however, circumstances often exist which simplify the study. Consider first the case where demand is too small to justify the installation of even the smallest producer unit, for either technical or economic reasons. There are manufacturing processes which have a definite minimum industrial scale, either because of the actual process or because of the type of equipment available on the market (for instance, the minimum size of rolling-mills in the steel industry, for different shapes and dimensions) or for other reasons. Naturally, the smallest size of equipment could be purchased, and worked below normal capacity, or special installations could be designed for lower production. The production costs in these cases would, however, be so high as to make economic production almost impossible.

These technical-economic factors thus establish a definite minimum justifiable production level, which becomes the lower limit of the production scale for the project.[33] This minimum scale may also have a decisive effect on the degree of precision required in the demand projection. Suppose that the demand for a certain product is 20 000 units a year, and, according to the projection, the rate of

[33] In the same type of industry, this scale may vary with the location. The minimum scale of motor-car manufacture in Europe is not necessarily the same as in the United States.

increase is so slow that many years will pass before it reaches 80 000 units. If, for any of the reasons mentioned, the minimum production is 80 000 units, it would obviously be unwise to set up the factory, and no price estimates will be necessary in making a preliminary estimation of the demand.

In other cases, demand may only be sufficient to justify the installation of a minimum size plant, but if this should be a type of industry where costs decrease in proportion to the increase in production, it is possible again that the installation would be unjustified, since the production costs would be too high in relation to ruling prices[34] There is no object in making a precise estimate in this case, if there is a great difference between the preliminary estimate of the volume of demand and the scale of operation made necessary by the competition.

A different case may arise when the demand is sufficiently large to permit, within reasonable limits, a number of new enterprises in the same branch of industry. The selected size of the project will not then depend upon the size of the market, but on other conditions which will be examined later.[35] The variation of demand resulting from price effect will have no influence in this case.

Finally, there is the case where the demand is greater than the minimum production scale, and is approximately the same as the capacity which the entrepreneur is prepared to install. If, for example, a demand is estimated to exist for 40 000 additional pairs of shoes each month, and factories can be installed to produce 40 000, 60 000 and 70 000 pairs, the manufacturer or the planner must take considerable care in estimating whether the new plant will cover the whole demand, or whether part will be satisfied by other manufacturers. The answer will naturally depend upon competitive circumstances, that is, if new technical or organization methods can be introduced which will ensure an adequate profit, even under highly competitive conditions. In this case it is obvious that prices and costs may be the deciding factors.

In short, the plan of analysis for a specific project should envisage three fundamental situations: (*a*) where the total demand is clearly less that the smallest productive unit which may be installed, for technical reasons; (*b*) where the demand is the same as the capacity of the smallest productive unit and (*c*) where the demand is clearly and with a wide margin—greater than the largest productive units which may be installed.[36] Correction of the demand projection in terms of prices will not be important if the estimated volume is very large; in this case, the individual producer may assume the present price relationship to be constant, evaluate the project and make his decision using margins of security for writing down the income or for increasing costs. If the market is very small, there is no object in proceeding with the project, and there is no point in making a projection of prices. If the preliminary estimate of total demand shows a figure equal to the minimum justifiable production capacity, it is important to go into details, and to consider the possible effect of prices. The greatest attention should then be given to the problem.

If the enterprise which will control the proposed industrial unit has a monopoly, it will be free to manipulate market prices over a fairly wide range. The projection of prices will have little importance in the evaluation, and will only influence the volume of demand if the product's price-elasticity is very high.

In most cases, private entrepreneurs can vary prices within the limits established by competition, and the projection of prices becomes one of margins of tolerance. Under these circumstances, the margins of security adopted for the calculations should be relatively large, and should protect the producer from risks arising from possible price changes. There is but little possibility that entrepreneurs will open a new line of production if demand is barely sufficient to justify the new unit, since in these cases it is more probable that demand would be satisfied by expansion of existing enterprises. An industrialist would only feel inclined to enter into a new field with such characteristics if he possessed a production process which would allow him to compete with established concerns; in general, in underdeveloped countries, industrialists only embark on new production when the unsatisfied demand is great, and in these cases the problem of projection of prices has but little importance for them.

### 3. *The public sector*

Although the above method of approach may be satisfactory for a project considered individually, it is not adequate when comparisons and priorities must be established, that is to say, when the projects must be evaluated. Comparison would be almost impossible if, instead of using a specific evaluation coefficient for each project, (or several coefficients, if different criteria are used simultaneously), a margin of variation were given for each coefficient separately, so that price alternatives could be examined.[37] The comparison will also be void if the magnitude of the evaluation coefficients should depend on more or less arbitrary modifications of prices as a function of certain margins of security, for instance. The inevitable subjectivity of such a projection becomes specially important when it is remembered that the different projects will generally be studied by several planners. It is most probable that different price criteria will be applied in each project so that the comparison and determination of priority will not have a homogeneous basis. The solution to this problem is found in the establishment of evaluation bases common to all projects, not only as regards the priority criteria which it is desired to employ, but also as regards the estimation of future input and output prices.

The problem of the influence of prices on the project study calls for a different treatment when government action is involved. The planner who is examining investment prospects which will be executed or decided upon by the public sector must choose between using current prices for all projects, or estimating future prices for all of them. The latter course involves a projection of the whole system of prices for each of the various sectors of the economy. This is an unjustified task if it is intended to prepare and evaluate only one, or very few projects, but is very necessary if priorities must be determined for the distribution of a specific amount of state resources between alternatives whose total cost is greater than the available amount. Remembering the very large sums which are often involv-

[34] Later it will be seen that there are cases where the increase in demand may justify operation with idle capacity in the early stages.

[35] See Part One, chapter IV.

[36] This will be dealt with more extensively in chapter IV, which covers the size and location of the project.

[37] In the second part of the Manual it is explained that the comparison is made by computing certain coefficients which are called "evaluation coefficients".

ed in public investments, the effort of making projections which will help to avoid possible waste of national resources appears to be well justified.[38]

### 4. *Conclusion and review of the approach*

The problem of the effect of future prices on demand is relatively simple to explain when an individual project is involved, to be assessed from the point of view of a private entrepreneur. To establish comparisons and priorities between a large number of projects, however, uniform price projection and general evaluation criteria have to be established. From the evaluation point of view, the complete solution of the price problem is beyond the possibilities of the project-maker, and must be included in the general priority standards which are established. All the data compiled will be included in the actual project, budgets for income and expenditure will be calculated in accordance with the various probable prices, and break-even points will be determined for the different levels of income and expenditure.[39] This type of analysis will be adequate for the private producer, but will be only one of the data required by the body which decides priorities.

[38] In order to project a coherent system of relative prices, it is essential to project also a group of variables, including national income, exports, total investments of the whole economy, and such others as form a part of the system of projections used in programming. Hence, formulation of a coherent system of priorities requires the previous establishment of a frame of reference bounded by the wider economic magnitudes, quantified for the future as a function of national aspirations or of what may be judged to be most probable economic development.

[39] The question of break-even points will be examined in Part One, chapter VI of the Manual.

## VII. The market study and "free" services

Both producers and consumers make use of various government services, for which they do not pay directly, and whose supply is generally governed by political decisions. Anyone who says that there is no demand for these services is mistaken. The citizen who writes a letter to a newspaper, or speaks with a local politician regarding the establishment of a school or a hospital, a police station or a health unit, is demanding government services even though he is not anxious to pay for them through taxation. It is possible, therefore, to speak of the demand for the "free" services supplied by the public sector, even though it cannot be computed by the methods explained earlier for a market study.

Some of the public services are used by the remainder of the producer system as inputs. If there were any technical relationship between the volume of production and the volume of this type of input which it uses, it would be possible to estimate the demand on the basis of the demand for the goods into whose production it enters. Unfortunately, such technical relations do not exist, and the volume of the services placed at the disposal of the users is determined as a function of decisions based on the general government policy (police, statistical services, scientific research). Where free public services are of direct benefit to the consumers (hospitals and education, for example), it is possible to employ quantitative relations to establish the probable volume of demand. There are statistical means for estimating the number of beds in a hospital per number of inhabitants, or the number of teachers per number of children of school age. Suppose that statistical series are available for *per capita* income in several countries with different income levels, and for the number of inhabitants per available hospital beds. It would then be possible to correlate the series, and estimate the value of the coefficient of income elasticity, for instance between the levels of 200 and 250 dollars *per capita.* Given this coefficient, and the rate of increase of income and population, it would be possible to calculate the number of beds required in future when the income level passes from 200 to 250 dollars *per capita.*[40]

This procedure does not pretend to offer a definite solution, and its only object is to simplify the formation of criteria which may lead to a decision. It is also obvious that it could be improved by allowing, for instance, for the differences between urban and rural population and other relevant factors. Further, it may be that the country is very poorly equipped with hospitals in relation to its level of income, and it is considered essential that this situation should be remedied as speedily as possible.

In view of the present economic conditions in many under-developed countries, it is usually impossible to give elementary education to the whole population. For this reason a rational target could be determined on the basis of a similar criterion to that suggested for hospitals. An examination of several countries shows that at *per capita* income levels of about 200 dollars there are approximately 100 children of school age for each teacher, whilst at the level of 500 dollars, the proportion is reduced to 31 children, and after this level there is no further reduction. Thus the increase of educational facilities may be determined in accordance with the growth of *per capita* income, as shown above. Table I gives some illustrative figures.

**Table I**

DEGREE OF DEVELOPMENT (1950) AND HOSPITAL AND ELEMENTARY EDUCATION FACILITIES[a]

| *Per capita income* | *Less than 200 dollars*[b] | *200 to 400 dollars*[c] | *400 to 600 dollars*[d] | *Over 600 dollars*[e] |
|---|---|---|---|---|
| *Hospital facilities* | | | | |
| Inhabitants per bed . . . . . | 321 | 202 | 104 | 99 |
| Inhabitants per doctor . . . . | 3 150 | 1 800 | 1 140 | 860 |
| *Educational facilities* | | | | |
| Children between 5 and 14 years per primary teacher . . . | 101 | 96 | 31 | 31[f] |

*Source*: Héctor Sosa, *Patrones para la programación de servicios sociales*, Santiago, 1955. Unpublished study prepared by the ECLA/TAA economic development training courses.
[a] The data for hospital and educational facilities are for different years, and the table has therefore only illustrative value.
[b] Brazil and Peru.
[c] Chile.
[d] Argentina, France and Norway.
[e] Denmark, Sweden, United Kingdom and United States.
[f] Excluding United Kingdom.

[40] If the elasticity is taken as 1.2, the annual increase of *per capita* income as 2 per cent, and that of the population as 1.88 per cent, the increase in *per capita* demand for beds would be 2.4 per cent (2 × 1.2) and the total requirement 4.2 per cent (1.8 plus 2.4) cumulative, per year.

For sewerage services, similar criteria can be used, remembering that such services are impossible without piped water supply, and if the latter is to be installed, sewerage can conveniently be installed at the same time.

It is very interesting to note that in some cases demand changes considerably when a service ceases to be free or consumption is more strictly controlled. In Bogotá, for instance, it has been established that, since the installation of water meters, the waste of water has been considerably reduced. During the period 1938 to 1942, the number of water meters increased from 20 per cent to 68 per cent, and during the same period the average *per capita* daily consumption fell from 230 to 170 litres. This reduction may be attributed almost entirely to the greater number of meters in use.[41]

[41] See "Agua para Bogotá", *Ingeniería Internacional, Construcción*, vol. 4, No. 4, April 1955, pp. 36 *et seq.* It is worth mentioning in passing that the same publication points out that in order to project the future water requirements for Bogotá, much importance was attached to *per capita* consumption in other Latin American cities.

## ILLUSTRATIVE CASES

### *Case 1*

### METHODOLOGICAL CRITERIA FOR PROJECTING DEMAND FOR CARS AND LORRIES

An outline is given here of the basic ideas governing the demand studies continuously undertaken by the Ford Motor Company, in order to determine selling prices for their products, plan their production policy and anticipate any necessary expansions in productive capacity and financing requirements (dividends and cash needs). Forecasts are made for 10 years. The data have been taken from a report prepared by this company as the result of a visit of Brazilian officials to its factories in the United States. During this visit, detailed discussions took place concerning the process and problems of making passenger cars, with a view to the possible installation of a factory in Brazil.[1]

Although the explanations given in that report are incomplete and cannot illustrate in every detail the methods followed, they do reveal the basic criteria employed and provide an example of how to apply many of the general principles explained in the text.

The company analyses demand by first finding out what the total demand will be and then estimating which part of that demand will be met by the company; the method used is different depending on whether it relates to lorries (capital goods) or cars (mainly durable consumer goods).

#### 1. *The demand for cars*

Demand for cars is projected on the basis that it originates mainly from two sources: an increase in the number of people owning cars and the need to replace them.

##### (a) *Increase in the number of cars*

It is assumed that the upward trend of the number of cars in use will continue. The reasons for this trend are as follows: (1) displacement of population from the cities towards the suburbs; (2) industrial decentralization within the country and displacement of population towards the West and South, in which regions the car is an essential means of transport, because public services are insufficient, and (3) increase in the number of family units owning more than one car, as a result of the rise in incomes.

[1] *Visit of the Brazilian Automotive Sub-Committee to Ford Motor Company—February 1953*, Vols. I and II.

Estimates relating to the increased number of cars in circulation are based on figures for future relationships between the number of cars registered and the number of dwellings, available personal income, employment and other variables. The criterion consisted in assuming that the trends of these relationships would continue. It was estimated that the total number of cars in the United States would rise from 39.8 million in 1952 to 49.5 million in 1961, which in turn is double the number of vehicles in circulation in 1941. The rate of increase in car licenses over the last years of 1950-59 tends to reflect the relatively low rate of formation of new families, which in turn is the result of the low birth rate during 1931-39. As from 1960, the rate of family formation will increase as a result of the high birth rates in 1940-49 and, will also be reflected in the number of car owners. It can be appreciated that this is essentially a projection based on income elasticity, considering both income distribution and demographic movements.

The report stresses some important figures concerning the rapid growth of dormitory areas around the great cities. Whereas the population of New York City increased by 4.7 per cent between 1940 and 1950, the suburban population rose by 22.6 per cent. In San Francisco, the city population increased by 21.8 per cent as against a suburban increase over the same period of 104.3 per cent. In a total of 12 large cities, population increases between 1940 and 1950 were 8.6 per cent as against a 34.8 per cent increase in their suburbs. Since owning a car is much more necessary to the suburban population, there is a trend towards owning more than one car per family unit. It was estimated that the number of cars for each 100 families would increase from 96.3 in 1952 to 106.7 in 1965, and that this will be largely due to the process just described, which will also be affected by the country's industrial decentralization.

The ratio of car ownership to income distribution is shown in table 1.

The "penetration" of cars on the market can be appreciated from the fact that even in the "under 2 000 dollars *per annum*" group, there are 37 cars for each 100 "consumer units". It can also be seen that as from the 3 000 to 5 000 dollar group, there begins to be more than one car per consumer unit. The long-term trend has been towards the increase of this ratio and it is anticipated that the trend will continue and will take a sharper upward curve over the next 10 years. Although the relative distribution of income between groups remains the same, as the absolute level rises, so do all the sectional incomes which, in turn, according to table 1, implies greater demand.

**Table 1**

CASE 1. DISTRIBUTION OF CAR OWNERSHIP BY INCOME LEVELS IN THE UNITED STATES, 1952

| *Income level per consumer unit[a] (Dollars)* | *Consumer units* (Percentages) | *Cars* (Percentages) | *Cars for every 100 consumer units* |
|---|---|---|---|
| Under 2 000 | 27.9 | 12.4 | 37 |
| 2 000 — 3 000 | 17.9 | 14.7 | 68 |
| 3 000 — 5 000 | 32.5 | 39.5 | 101 |
| 5 000 — 7 500 | 14.4 | 20.6 | 119 |
| Over 7 500 | 7.3 | 12.8 | 146 |
| *Total* | 100.0 | 100.0 | 83 |

[a] By "consumer unit" is understood the group of related persons who pool their income for larger expenditure items. In the case of a married son and his wife living under one roof with his parents, this is only one family but two "consumer units". The consumer unit is therefore somewhat smaller than a family and its total will be higher than the total number of families in a given country.

The report points out that in the United States the relationship between the price of a cheap car and net *per capita* income (after paying taxes) has remained more or less stable since 1930, although presentation and quality have both improved considerably. Project makers deduce from this that for every dollar invested in a car in 1952, the consumer "obtains more" than in 1930, which places the car in a better relative position *vis-à-vis* other consumer goods with which it competes for the consumer's available income.

### (b) *Replacement of worn-out cars*

The replacement market will account for about two-thirds of total demand in the next 10 or 15 years (studies in 1953). In view of this component's importance, the replacement process and scrapping of cars must be carefully studied. The following guiding principles were adopted in this connexion:

(1) Over 40 per cent of 1937 models were still in use in 1952, that is, when they were 15 years old. This is a very high percentage in comparison with the pre-war period, when scarcely 5 per cent of cars remained in use for 15 years. The difference was not only the result of the war, but of the fact that those cars which were 15 years old in the 1935-39 period corresponded to models of 1920-25 which, for technical reasons, did not last as long as the closed, all-steel cars introduced on the market thereafter.

(2) The estimate of average annual replacement over the 1952-61 period was based on the assumption that some part of the increased life-span of cars noted during the 1935-39 and immediate post-war periods would continue. To estimate the normal post-war life-span, it was borne in mind that the 1952 registration reflected the abnormal post-war shortage and involuntary maintenance of older cars.

(3) The average life-span, throughout the 1935-39 period, does not reflect its upward trend during these five years. An indication of that trend is shown by the percentage of cars in service which were 10 years old. The percentage of cars lasting longer than 10 years grew rapidly from 1935 to 1939, reflecting the revolutionary changes introduced in the 1925-29 models. From 1939 until the United States entered the war, the percentage of cars still running at 10 years varied very little and was around 60 per cent.

(4) During the car shortage following the war, the life of cars was considerably extended and percentages of survival were very high for cars of all models. With the return to a more normal situation, as anticipated for the 1952-61 period, it is assumed that the percentage of cars still running at 10 years will return to the level of the immediate pre-war period.

(5) Table 2 shows the distribution of cars by age during the years 1940-50 and 1952 and the projection made for the years 1955 and 1960.

(6) As can be seen from table 2, it was estimated that in 1955 there would be an abnormally high percentage of cars less than eight years old (due to the large number of new cars bought after the war, once production had been geared up). As a result, it is expected that replacement demand will drop as from that year.[2] The post-war models will, by 1960, have reached an age of heavy scrapping and replacement demand will increase.

### (c) *Total demand*

Based on this background, the authors of the study estimated that a reasonable projection of total car demand for the 1952-61 period would be from 4.5 to 5.0 million units per year. This figure was reached by combining the data relating to the total number of cars, projected previously, and the relative estimates of average age and life-spans, explained above.

Projected demand is higher than in the pre-war years but it will not approach—as might be assumed—that for 1950-51; these were years which caught up with the unsatisfied demand produced by war-time interruptions in output and by the reduction in car registrations as a result of the 1938 recession (see table 3).

## 2. *Demand for lorries*

As in the case of cars, this was based on the assumption that demand for lorries would be derived fundamentally from absolute growth in the number of these vehicles in circulation and from the replacement of those withdrawn from use.

### (a) *Growth of the number of lorries in circulation*

The projection was divided into two parts: one relating

[2] In more general terms, it should be pointed out that this is a characteristic of durable consumer goods; even though future income may rise steadily, there may be demand peaks for some years, because of previous cycles and the fact that an important component of demand is the replacement of outworn units.

**Table 2**

CASE 1. DISTRIBUTION OF CARS BY AGES IN THE UNITED STATES

*(Percentages)*

| | *Under 8 years* | *8 to 14 years* | *Over 14 years* | *Average age* |
|---|---|---|---|---|
| 1940 | 72 | 26 | 2 | 5.3 |
| 1950 | 46 | 45 | 9 | 7.3 |
| 1952 | 66 | 24 | 10 | 6.3 |
| 1955[a] | 77 | 16 | 7 | 5.6 |
| 1960[a] | 66 | 33 | 1 | 5.6 |

*Source:* Visit of the Brazilian Automotive Sub-Committee to Ford Motor Co., February 1953.
[a] Estimate.

Table 3

CASE 1. TOTAL SALES OF CAR FACTORIES IN THE UNITED STATES

| *Year* | *Millions of cars* |
|---|---|
| 1925 | 3.7 |
| 1928 | 4.6 |
| 1932 | 1.1 |
| 1937 | 3.9 |
| 1938 | 2.0 |
| 1946 | 2.1 |
| 1950 | 6.7 |
| 1952 | 4.3 |
| 1952-61[a] | 4.5—5.0 |

[a] Estimated annual average.

to future demand for rural and the other for non-rural lorries. The demand projection for non-rural lorries was based on the correlation between the rates of growth in the number of lorries and of non-agricultural production in general. According to the report, the historic relationship reflects to some extent the displacement of railway freight to lorries. Nevertheless, when making the projection, a lower substitution rate of railway for highway freights was assumed. On the basis of these criteria, demand for non-rural lorries was projected up to 1961 and a linear interpolation made between 1952 and 1961[3] to find out the demand for the intermediate years. The average annual demand was shown to be 140 000 units, which represents a total increase of 24 per cent over the 10 year period (from 5.8 to 7.2 million).

The study points out that, based on the correlation between United States industrial production and lorry output, it was estimated in 1947 that total lorry production would average 1.2 million units per year in the four following years. Actual production in these four years was 4.9 million units, which means that the 1947 projection was an excellent approximation.

The demand projection for rural lorries was based on the projection of agricultural production over the next 10 years, according to which lorry demand will rise from 2.3 million units in 1952 to 3.0 in 1961. According to a forecast based on the number of farms in the United States, the increase would be 5 million in 1961; this means that the demand projection for rural lorries would imply for that year 60 lorries per 100 farms as against 42 lorries for each 100 farms in 1951.

(b) *Demand corresponding to replacement of lorries withdrawn from circulation*

The criteria used here were similar to those used in the case of cars, and compared the survival at different ages between the pre-war and post-war periods. It was pointed out that the important technical improvements in production and design lessened the possibility of a return to the relatively short life-span of the period 1935-39.

It was concluded, therefore, that a reasonable forecast of the total lorry demand for the 1952-61 period would range from 1.0 to 1.3 million units per year.

3. *The company's share in the total market*

Information on this point is naturally somewhat restricted, because of the very nature of the problem; nevertheless, the basic assumptions put forward in the report in this connexion refer, firstly, to the percentage of total demand that would be supplied by the low-priced makes of car (Chevrolet, Ford, Plymouth). It was anticipated that, thanks to sales policy, these three makes would supply, in 1961, some 58 per cent of total demand for cars, as against 54.9 per cent in 1952. The second assumption concerned the Ford Company's share in the percentage increase in the demand for cars of these three makes, i.e., what changes there would be in the relative proportions of the market supplied by Ford and its competitors.

The "indicators" referred to in the study for analysing these relative changes in the market are prices at auction sales for cars and surveys relating to consumer preference. For this, the company uses various techniques in order to find out the design features that must be incorporated into its cars and lorries to improve their competitive position. All begin with surveys to discover the public's reaction to the current year's models and to ask specifically what make of car people plan to buy the following year. The replies are tabulated and analysed in order to obtain a guide to the trends in consumer preference.

[3] The report gives no details as to the magnitude of the correlations mentioned.

### *Case 2*

### PROJECTION OF FREIGHT AND PASSENGER TRAFFIC IN A RAILWAY STUDY

The next example is taken from a technical study carried out with a view to rehabilitating the *Ferrocarril del Pacifico* in Mexico, and which served as a basis for requesting a loan from the International Bank.[4]

The demand analysis was undertaken with two fundamental objectives in view: (*a*) to determine whether in principle the probable traffic developments justified the rehabilitation and re-equipment of the railway; (*b*) to determine whether potential income would financially justify the corresponding investments.

To project traffic, an attempt was first made to obtain an over-all view of the economic development of the area served: future demand for railway services was then estimated on the basis of commodity groups, as explained later. Traffic was projected in tons, and to estimate future income the tonnage was multiplied by the average income per ton obtained in 1952. The price problem—in this case that of freight rates—was resolved on the assumption that they would vary in proportion to operating costs. In other words, it was accepted that there was stability in the price ratios of railway services and the input needed to produce them. Incidentally one great simplification was to calculate traffic in tons and not in ton-kilometres. This involves the assumption that the average distances run would remain the same, thus permitting income to be calculated in the manner explained.

Once the traffic for each commodity group and for passengers has been projected, the total income from operating the railway can be projected.

[4] Subsequently, after the project had already been submitted to the International Bank, the figures were brought up to date and the influence of monetary devaluation was considered. The complete outline of the study and its technical characteristics are given in case 17 and the financing of the rehabilitation project is explained in case 43. All the figures used in these examples represent preliminary estimates carried out at the study stage of the project and do not pretend to reflect the current position.

The projection period for the first study was 10 years as from 1953, which was taken as the base year, with figures estimated on the basis of statistical data for 1952. This projection period was adopted in view of the financial aspects of the problem mentioned earlier.

The summary which follows covers three points: (1) description of the area; (2) traffic projection; and (3) summary of total income.

### 1. *Description of the area*

The railway operated in four Mexican States, in the northwest of the country. These States, Sonora, Sinaloa, Nayarit and Jalisco, include 18 per cent of the country's area and produce a growing volume of agricultural products for export. Most of the demand for manufactured goods has to be met from other zones. At present, about 50 per cent of the tonnage hauled consists of agricultural commodities, 20 per cent industrial and 10 per cent petroleum products. Passenger traffic is not large.

Over 50 per cent of tthe freight traffic is local. Approximately 35 per cent is traffic connecting with other Mexican railways or coming from them, and the remainder is traffic with the United States. This last has not grown in recent times, nor is much increase anticipated, as will be seen shortly. As a rule the area's development has been more rapid than that of the country as a whole, and this trend is expected to continue. The coastal plain comprises some 3.5 million hectares suitable for agricultural production. Annual precipitation is low in the north (some 100 mm) but rises to over 1 000 mm in the south. The rainy season is in the summer months and, providing adequate measures are taken, the water can be used for agricultural purposes, except in the north, where the underground water level is very close to the surface and irrigation has been developed successfully by means of pumping from wells.

The Government has built an integrated system of dams and canals and there are now some 700 000 hectares of irrigated land. Other projects at the study or construction stages would bring this figure up to 1.8 million hectares over the next 10 years. This would mean irrigation of approximately half the land suitable for agricultural purposes, and half the average annual flow of the rivers would be used. Cotton is the dominant crop in the north; further south, wheat takes first place, over 25 per cent of the country's total output being harvested there. Still farther to the south, the crops are sugar cane and winter vegetables, mainly tomatoes, more than half of the country's total tomato crop being grown in the area. The majority of the farms are large and most of them are mechanized. The farmers show considerable initiative and technical levels of cultivation appear high. Natural conditions favour crop rotation, but this is not yet widespread. Stock breeding is well developed in the north, but is of little importance in other parts. About 85 per cent of the country's total fishing activity takes place on the coast of this region. Manufacturing output is of less relative importance, the main products being sugar, beer and cement. The electrical power stations in the area have a capacity of about 50 000 kW, and new ones planned will raise this to 300 000 kW in 1960.

The population of the four states rose from 1.09 million in 1930 to 1.84 million in 1950, that is, by some 70 per cent. During the same period the country's population only increased by 56 per cent, which appears to indicate a higher rate of development in the region. This trend is expected to continue in the future.

### 2. *Traffic projection*

Transport of commodities and passenger traffic were considered separately. The following were important among the commodity groups: forest, agricultural, livestock, petroleum, inorganic and industrial commodities, official Government material and lighter traffic of less than a wagon-load. The method of procedure with agricultural commodities is summarized in some detail for illustrative purposes, but only a brief outline is given in the case of the other groups.

#### (a) *Forest products*

This group is not large quantitatively speaking, and consists mainly of wood and timber. It occupied only 1.7 per cent of the total number of wagons and 1.9 per cent of the tonnage carried commercially, resulting in 1.3 per cent of freight receipts. Approximately 60 per cent of the traffic is regional, 20 per cent consisting of imports from the United States and 15 per cent being sent to other parts of the Republic. The historic trend of this traffic has been a downward one, influenced somewhat by a national forest conservation and reafforestation programme to defend these natural resources. As a result of this programme, it is estimated that there will be no increase in the transport of forest products over the next 10 years, although there will be growth over a longer period.

On the basis of this information, freight would remain stationary over the projected period, averaging 36 000 tons a year, or the same as that averaged in 1949-52.

#### (b) *Agricultural commodities*

The *Ferrocarril del Pacifico's* greatest traffic is in agricultural commodities. For instance, in 1952 the volume of this traffic required 44.1 per cent of the wagons and represented 41.5 per cent of the tonnage and 49.8 per cent of the income from freight. The more important items are: cotton and its by-products, maize, wheat and wheat flour, tomatoes, peppers, melons, peas, sugar cane and rice. The report studies each of these separately. (See the summary of these figures in table 4.)[5]

*Cotton and by-products.* An analysis was made of the positive and negative factors affecting the traffic of this commodity by rail.

Among those factors which might result in a decline, or in relative variations from one year to another, in the growth of cotton production in the area served by the railway, the following are mentioned: crop variations due to the weather; the possibilities of storing cotton from one year to another; the possibility of transporting cotton seed as such or processed into oil; the danger that the United States will throw its surpluses on the market; the possibility that the Mexican Government may restrict the increase in cotton production to give preference to wheat production; the danger of the pink worm plague; the stability of the Mexican textile industry; and the pos-

[5] The original text of the report gives the results year by year. Only those for the first and last year of the period have been included, for purposes of illustration.

**Table 4**

CASE 2. TRAFFIC IN AGRICULTURAL PRODUCTS

*(Figures in thousands of units)*

| Classification | 1952[a] | Base year 1953[b] | Projection 1954 | Projection 1963 |
|---|---|---|---|---|
| *Tons* | *749.0* | *828.1* | *926.2* | *1 726.0* |
| Cotton and cotton-seed | 139.0 | 140.0 | 147.0 | 210.0 |
| Maize | 92.0 | 100.0 | 111.0 | 210.0 |
| Wheat | 120.0 | 207.0 | 255.0 | 682.0 |
| Wheat flour | 12.0 | 7.0 | 7.0 | 7.0 |
| Tomatoes | 88.0 | 90.0 | 91.0 | 100.0 |
| Peppers | 11.2 | 10.0 | 10.3 | 12.5 |
| Melons | 6.2 | 10.0 | 11.0 | 20.0 |
| Peas | 3.1 | 3.5 | 3.7 | 5.3 |
| Sugar-cane | 84.2 | 80.0 | 80.0 | 80.0 |
| Rice | 34.0 | 15.0 | 25.0 | 54.0 |
| Others | 161.1 | 165.0 | 185.2 | 345.2 |
| *Income in pesos* | *52 365* | *54 192* | *60 208* | *109 404* |
| Cotton and cotton-seed | 6 797 | 6 800 | 7 143 | 10 225 |
| Maize | 2 877 | 3 200 | 3 544 | 6 633 |
| Wheat | 7 688 | 13 306 | 16 406 | 44 306 |
| Wheat flour | 471 | 268 | 268 | 268 |
| Tomatoes | 15 820 | 15 640 | 15 815 | 17 390 |
| Peppers | 1 943 | 1 720 | 1 763 | 2 150 |
| Melons | 1 039 | 1 740 | 1 914 | 3 480 |
| Peas | 578 | 613 | 643 | 913 |
| Sugar-cane | 156 | 160 | 160 | 160 |
| Rice | 2 298 | 975 | 1 625 | 3 510 |
| Others | 9 495 | 9 770 | 10 927 | 20 367 |
| Adjustment in income[c] | 3 203 | — | — | — |

[a] Actual figures.
[b] Estimates.
[c] Inter-linear traffic.

sible competition from lorries for carrying export cotton to the ports.

Factors encouraging cotton traffic by rail would be: the transport installations built by a certain foreign firm, which implies an intention to continue using the railway; the possibility that a certain tonnage of cotton, habitually exported through the United States ports in California, may be diverted to a Mexican port because of advantageous port charges; and the possible increase in production through the extension cotton growing to new land.

According to this type of analysis, it was estimated that traffic in cotton and its products would increase at the rate of 5 per cent a year over the 1953 volume, which represents 7 000 tons per year.

*Maize.* Estimates were based on the premise that the Government is interested in increasing maize production, and will therefore try to encourage it on the new land incorporated annually into farming. To calculate the probable traffic, it was assumed that the present *per capita* maize consumption would continue (125 kilogrammes per year); the population increase would thus mean that, by 1960, 4 million tons would be needed. The states of Sonora, Sinaloa and Nayarit, which are within the area served by the railway, have over the last few years produced from 6 to 10 per cent of the country's total maize crop.

On the basis of the area under irrigation and the suitability of the climate, it was estimated that this same zone would produce 9 per cent of national output at the end of the projection period, that is, 360 000 tons. It was considered reasonable to expect that the railway would move 50 per cent of the crop (180 000 tons); this represents 95.3 per cent more than in 1952, when the harvests were relatively poor. Briefly, then, there would be an annual traffic increase of about 12 per cent between 1953 and 1960 (11 000 tons per year). On the basis of average receipts in 1952 (31.22 pesos per ton), the increase in income would be 343 500 pesos per year.

*Wheat and wheat flour.* This is a basic food which continues to be imported, even though it is sown in large quantities. It was estimated that wheat production ought to increase as a result of the efforts made to substitute the respective imports, and that a large part of the increase would take place in the zones served by the railway. As a source of income for the railway, this commodity takes second place after tomatoes.

To calculate the probable volume of wheat and wheat flour traffic carried by the railway, a preliminary estimate was made of the larger producing areas, considering irrigated zones and those shortly to be brought under irrigation. It was concluded that production would rise from 250 000 tons in 1953 to 650 000 in 1960, that is, that the increase would be 160 per cent during the period, at an annual average of 23 per cent.

These percentages of increase in production would also be the same for traffic, assuming the continuance of the historic ratios between volume produced and transported. Expansion of railway traffic in the same proportion will also depend on the railway's capacity to handle it.

Taking as a basis the 207 000 tons transported by rail in 1953 and applying to this figure the average annual increase of 23 per cent, the traffic increase would represent 47 500 tons per year, which, at an average of 64.28 pesos per ton (1952 rates), would mean an annual increase in income of 3.1 million pesos.

*Tomatoes.* From the point of view of income, this is the railway's most important freight item. The areas it serves produce about 50 per cent of the tomatoes harvested in the country, and the same areas supply about 75 per cent of Mexico's entire tomato exports to the United States. The volume of this commodity transported by rail depends more on demand in the buying markets than on output, because most of this is exported to the United States, and when tomato production rises in that country, the demand for Mexican tomatoes drops. On the other hand, only 40 per cent of the tomatoes produced are of the quality demanded by the United States market. The rest is tinned, consumed within the country or spoiled. Competition from lorry transport services was also considered, since in recent years these have captured a larger share of the traffic. The railway could recover it with a faster service, since it has refrigeration services, which avoids transfers at the frontier from lorries to refrigerated wagons.

The foregoing explains why, although tomato production is on the increase, the volume of traffic has varied from one year to another, within relatively constant limits. The report indicates that while it is expected that these fluctuations will continue, there are sufficient reasons to assume that the volume of export traffic will increase slightly, due to the improved railway service and the increased United States demand resulting from the growth of the population in general and that of California in particular. At the same time it was considered doubtful whether the railway could recover the traffic lost within the country to lorries, since these offer a faster service and lower rates.

The analysis served as a basis for estimating that tomato traffic carried by the railway under study would increase by 10 per cent over the next 10 years, equivalent to some 1 000 tons per year. Considering an average income of 173.74 pesos per ton, the greater annual income for tomato transport would be some 175 000 pesos.

*Melons, peppers and peas.* This commodity group represents the other large perishable export traffic to the United States. The analysis and forecast for the future was made in a manner similar to that explained above, the results being summarized below:

*Estimate of annual increase in railway traffic*

| | *Percentage* | *Tons* | *Receipts in pesos* |
|---|---|---|---|
| Peppers . . . | 2.5 | 250 | 43 000 |
| Melons . . . | 10.0 | 1 000 | 174 000 |
| Peas . . . . | 5.0 | 175 | 30 000 |

### (c) *Animal products*

In quantitative terms, this traffic is not large; in 1952 it required 4.9 per cent of the wagons and comprised 2.6 per cent of the tonnage and 3.2 per cent of total income. Although the number of head of cattle in the area served by the railway has increased substantially, there was at the same time a reduction in cattle shipments. Whereas in 1945 the railway carried 16.2 tons of cattle for every 1 000 head of the cattle population this figure dropped to 8.6 in 1950.

The projected development of irrigation works implies a long-range increase in livestock traffic; but in the absence of more specific data, it was assumed that the tonnage of animal products carried by rail would remain constant at 47 000 tons a year, this being the same figure as in 1952 and the lowest of recent years.

### (d) *Transport of other commodity groups*

The same type of analysis was undertaken for the rest of the freight carried habitually by the railway. Among petroleum derivatives, the following items were more important: lubricating oils and grease, asphalt, petrol, gas for fuel, crude oil, refined petroleum and other petroleum derivatives. In projecting industrial products the following break-down was used: beer, wines and spirits, returned empty containers, refined and unrefined sugar, molasses, cement, tanned hides and skins and other products.

The group of "official materials" includes the various goods used by the Government in its habitual activities and in special development projects. The projection was made by taking into account existing projects for irrigation, electric energy and road building. As for irrigation, it was pointed out that the 711 000 hectares of irrigated land existing in 1950 would be increased by 541 000 hectares in 1953 and that by the end of 1960 it was planned to add another 572 000 hectares. It was estimated that the volume of traffic originated by this work would be the same as the average for the past eight years, considering that in the last two years exceptionally large Government programmes had been carried out in the area.

The small freight of less than a wagon-load has been declining gradually because it is very susceptible to lorry competition. In recent years there has been a rapid increase in the number of lorry registrations (from 7 020 to 17 799 between 1945 and 1952).

### (e) *Summary of freight traffic*

A table was prepared for each of the commodity groups described, similar to that already shown for agricultural products. The traffic in industrial commodities, for example, would grow from 329 000 tons in 1953 to 505 000 tons in 1963 (53.4 per cent increase). The income derived from this same group would grow from 20.70 to 30.05 million pesos (45.1 per cent) over the same period. Despite these increases, the group's relative importance within the total traffic would decline from 18.2 to 16.2 per cent in tons and from 20 to 17.1 per cent in income. This would be basically due to the much sharper changes in the traffic in agricultural commodities, which would increase 108.5 per cent in tonnage and 101.9 per cent in income. Between the years 1953 and 1963 this second group's relative importance within total tonnage would increase from 45.7 to 55.5 per cent, and from 52.2 to 62.2 per cent within total income.

### (f) *Passenger traffic*

Passenger traffic carried by the railway shows a clear downward trend (see table 5).

It can be seen that between 1936-40 and 1952, the distance travelled per passenger shows a remarkable increase. In fact, whereas the index of the number of passengers remains practically stable, that of passenger-kilometres rises from 100 to 347. This is because labourers are travelling over longer distance and because of the decline in railway traffic for short distances, which has been taken over by buses. The average income per passenger

**Table 5**

CASE 2. RAILWAY PASSENGER TRAFFIC

| *Annual average* | *Passengers* (Thousands) | *Passenger-kilometres* (Thousands) | *Income in pesos* (Thousands) | *Indices* *Passengers* | *Indices* *Passengers-kilometres* | *Indices* *Income* |
|---|---|---|---|---|---|---|
| 1936-40 . . . . . . . | 526 | 129 156 | 3 585 | 100 | 100 | 100 |
| 1941-45 . . . . . . . | 791 | 279 117 | 8 471 | 150 | 216 | 236 |
| 1946-50 . . . . . . . | 676 | 329 607 | 14 145 | 129 | 255 | 395 |
| 1951 . . . . . . . . . | 511 | 427 903 | 19 582 | 97 | 333 | 546 |
| 1952 . . . . . . . . . | 515 | 448 434 | 23 472 | 98 | 347 | 655 |

has risen very sharply during the period analysed, because journeys are longer; but the average income per passenger-kilometre has only doubled, because of the great loss in first-class passenger travel. The report analyses competition from other means of transport (buses for short and aircraft for long distances) and shows the increased traffic in both means of transport in relation to the past.

It was estimated that railway fares cannot compete with aircraft for long-distance, first-class journeys, even though the railway fares are lower. Nor was it considered likely that the railway could compete with buses for shorter distances, either with regard to fares or to the frequency of the service. On the other hand, there was a growing demand for railway service for long-distance, second-class journeys and for the movement of parcels and postal services.

Even though further income reductions from passenger traffic may be anticipated, there would be a sufficient profit margin in this item to introduce improvements in the service compatible with the demand for second-class passages. On the other hand, the situation concerning first-class passages should be closely watched, because it may decline to the point where there is no justification for expanding or improving the service. According to the company's accounting, during the years 1951-52 income from passenger services did not cover their total share of operating expenses; nevertheless, by charging to the passenger service only those expenses that could be avoided if the service were eliminated, receipts turn out to be higher than expenditure.

Since in any case the use of cars, buses and aircraft may be expected to continue increasing, and in view of the time required to provide a satisfactory passenger service once again, it was estimated that, altogether, receipts from passenger traffic would decline, falling from the 19.2 million pesos estimated for 1953 to 15.6 million in 1956, with a tendency to remain stable as from that year on.[6]

### 3. *Summary of total receipts*

Table 6, which compares total receipts, shows quite clearly the extent to which the *Ferrocarril del Pacífico's* prosperity depends on its freight traffic.

Within this traffic, the most important items as indicated earlier, are agricultural, petroleum and industrial products.

## *Case 3*

### Projection of electrical demand in an urban industrial area

This case has been taken from the Chilean electrification programme[7] and is an example of projection of demand by extrapolation of trends. To localize the electrical problem (energy resources and consumption), Chile was divided into geographical regions. The following extract refers to the third geographical region. A technical appendix has also been attached to this example, to explain some of the technical terms relating to electrical demand, and to simplify the understanding of the text for readers who are not familiar with the subject.

[6] When the report was brought up to date, after the devaluation of the Mexican peso, effective figures were available for 1953. According to these, receipts in that year amounted to only 16.9 million pesos.

**Table 6**

CASE 2. PROJECTION OF TOTAL RAILWAY INCOME

*(Thousands of pesos)*

| | 1953 | 1963 | Percentage increase |
|---|---|---|---|
| Freight | 109 012 | 175 922 | 61.1 |
| Others | 34 659 | 34 938 | 0.8 |
| Total | 143 671 | 310 860 | 40.8 |

### 1. *Description of the region*

The third geographical region covers an area of 76 400 km² (10.3 per cent of all Chile) and in 1952 it held approximately 3 200 000 people (53.1 per cent of the total population). It is essentially an agricultural and industrial region, and is the most important and highly developed in Chile. It is divided into two electrical development and consumption zones, north and south of the River Maipo. The zone to the north has the largest population centres, the highest *per capita* consumption of public services in the country, and also considerable industrial consumption. The southern zone is mainly agricultural, with little development of electrical consumption.

The hydroelectric resources of the region are characterized by rivers depending on a glacial system (heavy thaw rises in the spring and beginning of summer, and very low water in autumn and winter). The major part of the economic or low-cost possibilities of generating hydraulic electric power in the northern zone has already been utilized, and it has now become necessary to consider those of the southern zone, moving away from the consumer centres.[8]

The economic importance of the region demands a high degree of security and continuity in the electrical service. Demand, which is concentrated mainly in the northern zone, is met by some public utility companies and by a number of private generating plants. Of these latter, distinction must be made between those which work continuously to meet the requirements of their industrial owners, and those which have been installed by industries as stand-by plants, to replace in emergency the power normally supplied by the power company.

The southern zone is largely supplied by ENDESA, a State enterprise, which provides power to the distributing enterprises and to rural co-operatives. The remaining distribution companies in the main cities of the zone also have their own generating plants, but purchase additional energy from ENDESA to meet the demand of their concession zone. Other electrical enterprises in the zone are solely distributors, and purchase the whole of their energy from ENDESA.

### 2. *Analysis and projection of demand*

The projection of demand is made on the basis of past rates of global increase in consumption. The basic series

[7] *Plan de electrificación del país para el periodo 1953-1964, Empresa Nacional de Electricidad, S. A.* ENDESA, and the Development Corporation (*Corporación de Fomento de la Producción*), Chile.

[8] More detailed explanations of natural hydroelectrical resources will be found in the technical appendix to case 4 of annex III.

used were those of peak maximum demand and gross output of energy[9] of the private producer enterprise which supplied 75 per cent of the area, and which has statistics covering more than 30 years. The output curve is similar to that of production, since losses have remained constant in a curve of aproximately 20 per cent. Monthly statistics have been used in turn to make up annual tables. The series show an irregular increase due to periodical shortages of available energy and lack of installed capacity in the system. This has become more accentuated in recent years, when electricity rationing became necessary. The enterprise made an estimate of presumptive demand, that is, what it would have been without rationing (see figure 1 and table 7).

During the period examined, years were selected when the supply was considered to be normal, and on this basis the average rate of increase of demand was determined (in terms of power). Normal years were assumed to be 1934, 1941 and 1945, although the last mentioned was influenced by the war. The year 1952 was added to the series, with assumed demand and output. The cumulative annual average increase was 8.4 per cent, but this figure was considered to be exaggerated when compared with the partial periods, which showed the following:

| *Period* | *Number of years* | *Percentage increase* |
|---|---|---|
| 1934-1952 | 18 | 7.15 |
| 1941-1952 | 11 | 7.10 |
| 1934-1941 | 7 | 7.25 |

[9] An explanation of the difference between power and energy is given in the technical appendix after this example.

**Figure 1**

CASE 3. ANNUAL STATISTICS OF PEAK HOURLY DEMAND AND ANNUAL PRODUCTION OF ENERGY

NATURAL SCALE

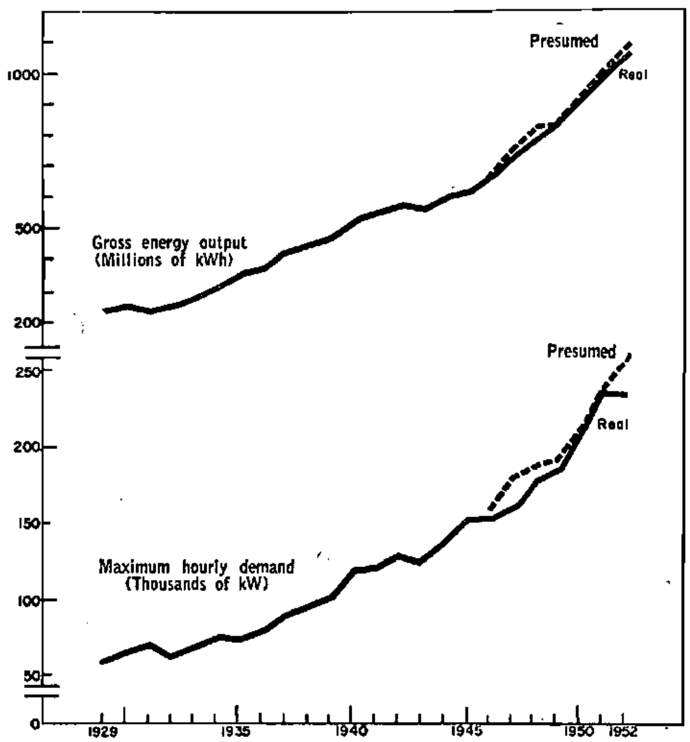


**Table 7**

CASE 3. ANNUAL STATISTICS OF PEAK HOURLY DEMAND AND OF ANNUAL PRODUCTION OF ENERGY

*(Real and presumptive figures had there been no restrictions)*

| *Year* | *Maximum hourly demand (Thousands of kWh)* | | *Gross energy production (Millions of kWh)* | | *Real average annual load factor* |
|---|---|---|---|---|---|
| | *Real* | *Presumptive* | *Real* | *Presumptive* | |
| 1920 | 19.5 | | 78.1 | | 45.7 |
| 1929 | 58.6 | | 232.1 | | 45.2 |
| 1930 | 65.0 | | 253.7 | | 42.8 |
| 1931 | 70.0 | | 242.8 | | 39.6 |
| 1932 | 63.2 | | 250.3 | | 45.3 |
| 1933 | 68.7 | | 277.3 | | 46.1 |
| 1934 | 74.1 | | 313.6 | | 48.2 |
| 1935 | 74.1 | | 345.7 | | 53.3 |
| 1936 | 78.7 | | 370.5 | | 53.7 |
| 1937 | 87.7 | | 421.3 | | 54.8 |
| 1938 | 95.0 | | 454.9 | | 54.7 |
| 1939 | 101.1 | | 475.9 | | 53.9 |
| 1940 | 117.1 | | 523.8 | | 51.0 |
| 1941 | 121.0 | | 549.3 | | 51.8 |
| 1942 | 126.2 | | 578.4 | | 52.2 |
| 1943 | 123.8 | | 568.0 | | 52.4 |
| 1944 | 136.9 | | 597.9 | | 50.0 |
| 1945 | 149.9 | | 621.2 | | 47.3 |
| 1946 | 152.0 | 157.7 | 668.9 | 676.1 | 50.2 |
| 1947 | 158.2 | 177.7 | 729.9 | 760.6 | 52.6 |
| 1948 | 174.7 | 185.0 | 784.7 | 831.1 | 51.2 |
| 1949 | 183.4 | 191.7 | 836.2 | 847.5 | 52.0 |
| 1950 | 207.9 | 209.8 | 913.4 | 913.4 | 50.2 |
| 1951 | 233.1 | 235.7 | 991.5 | 1 008.2 | 50.7 |
| 1952 | 232.3 | 257.0 | 1 063.4 | 1 089.1 | 52.2 |

In recent years the demand has increased by much greater amounts (13.4 per cent in 1950-51 and 11.2 per cent annual average 1950-52), but this is explained by the abnormal increase in electrical domestic heating, resulting from low rates, which must be revised in order to adapt them to a more suitable economic policy.[10]

On the basis of the above figures, ENDESA considered 7.2 per cent cumulative annual increase of demand to be a reasonable figure for the system served by the private enterprise. The projection of this rate of increase would be made starting from the assumed consumption and demand of 1952.

The demand for the remaining enterprises which supplied electrical energy in the northern area were projected applying the same coefficient of 7.2 per cent annual increase.

The demand on the large industries with interconnected private generating plants, which sold their surpluses, was 24 800 kW in 1952 for their own use. The cumulative increase of this industrial demand was estimated at 3 per cent annually.

Industries which owned stand-by plants, which did not work continuously, should not be considered in the case of ample availability in the public supply network. The power demand of these industries has been estimated at 9 500 kW, and their increase also at 3 per cent.

The southern zone has a number of electrical enterprises and rural co-operatives. Since consumption has been rationed, and since the ENDESA works will reach districts where hitherto there has been no supply, a larger increase was estimated here than for the northern area. As from 1950 a cumulative annual increase of 9 per cent was adopted for some districts, and 10 per cent for others.

The above projections have been made in terms of demand expressed in power. To make the projection in terms of output of energy, it was assumed that the present load factors would be maintained (see table 8).

The high load factor may be seen in industries which have plants to supply exclusively their own requirements.[11]

[10] An undesirable change, since it would benefit higher income consumers to the detriment of industrial production. In this case a comparison must be made between electric energy as an end-use product in domestic heating, and as an input into industry. With low rates and very low costs of electrical concessions, the consumers save the initial cost of some other type of heating—central heating for example.

[11] The technical appendix following this example explains load factors.

**Table 8**

CASE 3. ELECTRIC ENERGY LOAD FACTORS, 1952

*(Percentages)*

| | |
|---|---|
| Private companies | 48.4 (Presumptive figure) |
| Industry | 91.3 (Real figure) |
| Total electricity companies in the northern zone | 39.1 (Real figure) |
| New distribution and cooperative enterprises | 38.2 (Real figure) |

It is also seen that the load factor of the private enterprise which supplies three-quarters of consumption is higher than the remaining enterprises, which have less diversified consumption.

The above calculations were carried to a final table showing the maximum annual power demand of each electrical enterprise, or group, related to the selected rates of increase, and to the maximum hourly power, year by year, in the whole region. A similar table showed the energy which must be produced, specifying the load factor in each case. A summary of the two tables was made in a third general table of forecast of demand (see table 9). In this table, the private company's area has been separated from the remainder, including in it the industries which produce their own power, but which are within the area of the concession. None of these considerations of the third region included a copper mine having its own plant, which is not interconnected.

## Technical appendix on electrical demand

### 1. *Expression of demand*

The expression of demand requires the use of certain technical terms whose meaning is explained in this appendix to facilitate understanding. The first point is the difference between power and energy.

Power is measured in kW, in h.p., or in equivalent units, and represents the capacity for producing work. Energy is measured in kilowatt-hours, in h.p.-hours, or in similar units, and represents the work actually done. Input into production is useful work done, that is, it is energy, meas-

**Table 9**

CASE 3. FORECAST OF ELECTRIC ENERGY DEMAND AND PRODUCTION FOR SEVERAL YEARS OF THE PERIOD 1935-64 FOR THE THIRD GEOGRAPHIC REGION OF CHILE

*(Thousands of kWh)*

| Year | Concession zone of the private company (Zone A) | | Rest of the third region (Zone B) | | Total for the third region | |
|---|---|---|---|---|---|---|
| | Peak winter hourly demand | Annual production | Peak winter hourly demand | Annual production | Peak winter hourly demand | Annual production |
| 1950 | 240.0 | 1 147 200 | 23.1 | 79 400 | 263.1 | 1 226 600 |
| 1951 | 268.9 | 1 254 300 | 25.5 | 87 000 | 294.4 | 1 341 300 |
| 1952 | 291.3 | 1 363 100 | 27.9 | 96 000 | 319.2 | 1 459 100 |
| 1953 | 310.8 | 1 449 500 | 30.3 | 104 300 | 341.1 | 1 533 800 |
| 1960 | 491.7 | 2 247 500 | 52.9 | 182 200 | 544.6 | 2 429 700 |
| 1964 | 641.0 | 2 900 200 | 73.2 | 252 000 | 714.2 | 3 152 200 |

ured in kWh. The power employed to produce this work must also be specified, so that demand must be expressed both in terms of power and of energy, or work.

The difference between power and energy, or work, may be seen from a simple case of residential consumption, where the meter shows that 10 kWh have been consumed during the month. This information does not provide a good reflection of the characteristics of the demand for this consumption, since the same figure could be obtained in many different ways, such as a single 100-watt lamp burning for 100 hours during the month, or by 10 lamps of 100 watts each burning for 10 hours during the month. The consumption in kWh is the same in both cases, but the demand would be substantially different in terms of the power of the generator which supplied the energy. In the first case, a 100-watt generator would be sufficient to maintain the single lamp alight, but the second case would need a 1 000 watt (1 kW) generator.

This explains why consumption tables generally include two series of data: one for energy consumed during a given period (say a year) and another expressing the power of the generating system during a specified time, within the chosen interval.

The demand over a number of years in the electrical system supplied by an electricity company is given in the manner shown in table 10.

The load factor (last column of table 10) expresses the relation between the hypothetical average power during the year and the maximum power required during one hour (peak hourly demand) during the year (first column). For 1946, for example, the load factor is obtained from the following calculations:

(*a*) Divide the gross annual output by 8 760—the number of hours in a year—giving the average hourly power of 76 350 kW;

(*b*) Dividing this average power by the maximum (152 000 kW according to table 10), gives a load factor of 0.502, or 50.2 per cent.

The load factor is of considerable economic and technical importance, because it measures the extent of utilization of the installation. For the same rated capacity, a higher load factor means the use of more energy, which will undoubtedly lead to a lower cost per kWh. The higher the load factor, the greater the utilization of the same installation in terms of total energy produced, which constitutes the input in productive processes and the end-product in domestic and other uses. Industrial or transport demands give higher load factors, since the load is maintained for longer periods of the day. Domestic demand, on the other hand, tends to give low load factors, since it is concentrated in a few hours daily.

The load factor may also affect electrical rates, since consumption must be encouraged during low-demand periods, to make maximum possible use of the installation at those hours. This often occurs in railways, when time-tables can be arranged for increased work at night or at periods of low consumption.

Summarizing: (*a*) the better the consumption is spread, in terms of time, the better will be the load factor of the system or power station; (*b*) this division of time may refer to the 24 hours of a day, to the seasons of the year, or to the complete year; according to the specific problem, daily, seasonal or annual load factors are used; (*c*) there can be a load factor for the whole of a system, or by consumer sectors, since the average load factor is the weighted average of partial load factors; (*d*) when demand is specified in terms of peak power, a specific load factor is implied.

**Table 10**

CASE 3. ELECTRICITY DEMAND

| *Year* | *Peak hourly demand (Thousands of kW)* | *Gross annual production of energy (Millions of kW)* | *Average annual load factor of the system* |
|---|---|---|---|
| 1946 . . . . . | 152.0 | 668.9 | 50.2 |
| 1947 . . . . . | 158.2 | 729.9 | 52.6 |
| 1948 . . . . . | 174.7 | 784.7 | 51.2 |
| 1949 . . . . . | 183.4 | 836.2 | 52.0 |
| 1950 . . . . . | 207.9 | 913.4 | 50.2 |
| 1951 . . . . . | 223.1 | 991.5 | 50.7 |
| 1952 . . . . . | 232.3 | 1 063.4 | 52.2 |

### 2. *Other technical definitions relating to demand*

In addition to the above, there are other technical expressions which contribute to the definition of the characteristics of electrical demand.

The demand on a system in terms of power is defined as the load on the output terminals of the system's source of supply, averaged for a specified adequate period of time, which usually ranges from 15 or 20 minutes to 1 hour. Demand is expressed in kilowatts, kilovolt-amperes or other convenient units. The fact that this is taken at the output terminals means that transmission or distribution losses are an additional load, and must be added if the output required to meet the demand is to be known.

The demand or connected load of a system, or part of a system, is expressed in terms of power, and is the sum of all the partial loads which may be placed on the system, and which, as their name implies, are connected to that system, in order to established a demand at any moment. (For instance, an industry may have a connected load of 1 000 kW, although its maximum demand is only 800 kW.) The sum of all connected loads is the connected total demand of the system. The maximum power demand, or peak load, of an installation or system is the greatest demand which may occur during a given time, within a definite interval. For instance, one may speak of the peak summer load during 30 minutes, or the peak load in three winter months for one hour (hourly demand).

The demand factor is the ratio of maximum demand to total connected load.

The diversity factor is the ratio of the sum of the maximum partial demands to the total maximum during a given time interval.

The plant factor is the ratio of the average power demand to the total rated capacity. When the maximum power load and the rated capacity are equal—that is, when there is no excess of rated capacity over peak load—the plant factor is the same as the load factor explained earlier. The plant factor, therefore, shows the percentage of rated capacity used during a given time interval (a year, a season, a month, etc.).

The same calculation can also be expressed as the utilization factor, which may be measured in two ways. One is to divide the equivalent number of operating hours at full load by 8 760, which will give the plant factor. In the other, the number of kWh generated is divided by the rated capacity. This latter form of expression, $\frac{\text{kWh}}{\text{kW installed}}$, is simply the plant factor multiplied by 8 760, since by definition the kWh generated are the average power demand multiplied by 8 760.

The power factor of consumption has a strictly technical interpretation, but may have great economic importance. In alternating current systems, which are the most common, there is a difference between nominal power, expressed in kilovolt-amperes (kVA) and the effective power, which is that which may be utilized in the production of mechanical work, and which is expressed in kW. The effective power is the product of the nominal power and the power factor, whose maximum value is unity. This means that the higher the power factor, the higher will be the percentage of nominal power utilized.

The power factor depends on the electrical characteristics of the distribution and consumption system, and can be improved by the installation of condensers or by other expensive complementary methods. The optimum solution is therefore a problem of generating and distribution of electrical energy, which affects installation costs, equipment specification and the electrical ratio policy.

The transmission of alternating current involves serious technical problems, and may cause large losses. Rates are therefore often studied which require clients to supply the whole or part of the elements needed to improve the power factor in electrical circuits.

Finally, to define electrical consumption, the voltage and frequency at which the consumers will use the energy must be specified.

### 3. *Technical definitions relating to supply*

The firm power of a hydroelectric plant is the load which it can carry at any time, with sound hydrological security.[12] It is determined by the minimum discharge from the river, and by the flow in cubic metres per second, including possible storage.

Surplus or secondary hydroelectric power is the part in excess of the firm power during certain periods. It is determined by hydrological conditions and installed capacity. In some instances secondary power is sold, but without guarantee of continuous service, since it is only supplied when it is available. It may be used, for instance, for pumping water for irrigation or for electrical recuperation.

The rated capacity of turbines is expressed in horsepower, for the head and speed which give the highest efficiency. Each of these factors may vary widely.

The rated capacity of alternating current generators is usually expressed in kilovolt-amperes, for specific speeds, and depending on the power factor and temperature rise. Each of these factors may also vary, but within definite limits. (For instance, there will be variation depending on the average available flow, hydrological security, etc.)

## *Case 4*

### Demand projection for electricity in the study of Brazilian economic development

This example is taken from the joint study prepared by ECLA and the *Banco de Desenvolvimiento Economico do Brasil*, entitled *Economic development in Brazil*.[13] Only the part relating to demand for electric energy is reproduced here, but the study mentioned approaches the whole problem in broader terms, since it covers programming for the entire energy sector.

### 1. *Approach*

Because of the prospects of a relative decline in Brazil's capacity to import, the starting point taken for the projection of demand was the need to intensify the use of hydroelectric energy. Despite the broad recognition of this need, experience over the past 10 years shows that hydroelectric energy has to a large extent been replaced by energy produced with liquid fuels. This substitution is evident in the case of urban transport in cities like Rio de Janeiro and São Paulo, where the electric trams have been replaced by combustion-engined buses.

Demand projection for electric energy meets with a series of difficulties caused mainly by the inadequacy of statistical data. To this must be added the fact that consumption has been heavily restricted through a shortage in the supply. To project the present position would therefore be to assume that this abnormal situation will continue. The solution to the problem may lie in preparing an inventory of present shortages, sector by sector. Some such attempts have already been made but the results, apart from being incomplete, are of doubtful value. It is known that, when enterprises detail their unsatisfied requirements, the tendency is to exaggerate them for various reasons. In addition, present unsatisfied needs are usually confused with expansion plans for the more or less distant future. The most satisfactory solution will probably be to base the projection upon the year 1949, when the supply shortage was only just beginning to appear. Furthermore, projections based on that year enable the data from the census to be used (see tables 11 and 12).

Accepting the initial premise of using the maximum possible amount of hydroelectric energy, the basic criterion for estimating future electricity demand was to make the projection separately for each economic sector, as is done in table 11, that is, industry, transport, public lighting, commerce, and household lighting.

[12] Hydrological security is the probability of a certain minimum flow. It is expressed as a percentage.

[13] E/CN.12/364/Rev. I, United Nations publication, Sales No. 1956.II.G.2, which is Vol. II of the series *Analyses and projections of economic development*. See chapter IV, especially pages 146-151.

**Table 11**

CASE 4. DISTRIBUTION OF ELECTRIC ENERGY CONSUMPTION IN BRAZIL

| | *1939* | *1949* |
|---|---|---|
| Total consumption (millions of kWh) | 2 488.7 | 6 237.2 |
| | *Percentage* | |
| Industry | 31.2 | 47.2 |
| Transport | 10.2 | 7.2 |
| Railways | 3.2 | 5.0 |
| Urban | 7.0 | 2.2 |
| Public lighting | 6.7 | 6.0 |
| Commerce | 13.9 | 8.6 |
| Household lighting in capital cities | 10.9 | 15.6 |
| Unspecified[a] | 27.1 | 15.4 |

*Source: The Economic Development of Brazil, op. cit.,* table 117.
[a] Including household lighting outside capital cities.

Table 12

CASE 4. BREAKDOWN OF ELECTRIC ENERGY CONSUMPTION BY MANUFACTURING INDUSTRIES IN BRAZIL

*(Millions of kWh)*

| *Industry* | *1939* | *1949* | *Percentage increase* |
|---|---|---|---|
| Non-metallic minerals. | 48.8 | 255.6 | 423.8 |
| Metallurgy. . . . . . | 69.0 | 381.3 | 452.6 |
| Foodstuffs. . . . . . | 148.1 | 600.8 | 305.6 |
| Textiles. . . . . . . | 261.1 | 629.7 | 141.2 |
| Chemicals . . . . . . | 74.1 | 284.5 | 283.9 |
| Paper . . . . . . . | 33.4 | 134.0 | 301.2 |
| Others . . . . . . . | 141.3 | 656.0 | 364.3 |
| Total. . . . . . | 775.8 | 2 941.9 | 379.2 |

*Source: The Economic Development of Brazil, op. cit.,* table 118.

The study was made in 1954 and the projections extend to 1962.

### 2. *Industrial demand*

The future demand for energy by industries was based on the projections of production for each branch of industry. This projection involved a forecast of the replacement of manpower by machinery (mechanization) or the use of equipment of more advanced technical design (higher yield in the use of electricity). All such modifications cause changes in the relationship between the volume of production and the consumption of energy, as can be seen by comparing the growth of connected power with the size of the labour force in the principal industry groups. As regards manufacturing industries as a whole, the growth in installed horse-power was 50 per cent greater than the number of workers. But while this difference was only 12 per cent in the textile industries, in metallurgy it reached 144 per cent. These comparisons are only of relative value since they do not refer in any way to the degree of utilization of equipment. In any event, since equipment utilization was generally more intense in 1949 than in 1939, the indices presented here reflect the minimum mechanization which must have taken place.[14]

The projection for electricity demand assumes that the mechanization process will continue in the near future (until 1962) at a rate approximately equal to that shown in the period 1940-49.

The study showed that there are three factors which determine the increase in electric energy consumption by industries: (*a*) growth of industrial production, (*b*) increased mechanization (i.e., increased horsepower—secondary motors—per worker), and (*c*) greater efficiency in energy utilization.

For the projection corresponding to each industry group, the following assumptions were made: (*a*) that industrial production would grow in accordance with the objectives forecast by the study of economic development of Brazil; (*b*) that the mechanization process would continue at the same rate of development as in the 1939-49 period; (*c*) that efficiency in the utilization of energy would remain constant. On these premises, the projection obtained was that shown in table 13. According to this table, the rate of annual growth in electric energy consumption in manufacturing industry would be 9.4 per cent, a relatively modest figure when compared with the 14.2 per cent for the period 1940-49.

### 3. *Transport*

According to the projections studied for the transport sector, electric energy consumption would increase in this sector by 1945.4 per cent, that is, at an annual growth rate of 7.1 per cent, which compares favourably with that of 5.8 per cent for the period 1940-49. It is assumed that there will be a recovery in urban electric transport with a substantial expansion in the number of trolleybuses.

### 4. *Public lighting*

Projection of energy consumption in public lighting is based on a series of data referring to State capitals and the Federal District, which has been available since 1944 and reflects an annual growth rate of 5.2 per cent. This

[14] The study points out that in the textile industry, for example, it is known that in 1939 part of the capacity remained idle, whereas in 1949 many mills were working more than one shift. The difference of 12 per cent thus under-estimates the mechanization introduced in this industry during the period under review.

Table 13

CASE 4. PROJECTION OF ELECTRIC ENERGY CONSUMPTION BY INDUSTRIES IN BRAZIL

| *Industries* | *1949 consumption (Millions of kWh)* | *Increased consumption forecast for 1949 and 1962, derived from* | | | *Probable consumption in 1962 (Millions of kWh)* |
|---|---|---|---|---|---|
| | | *Increased production* | *Greater use of machinery* | *Total* | |
| | | *(Percentage)* | | | |
| Non-metallic minerals . . | 255.6 | 206 | 32 | 230 | 864 |
| Metallurgy . . . . . . . | 381.3 | 289 | 206 | 495 | 2 269 |
| Foodstuffs . . . . . . . | 600.8 | 82 | 68 | 150 | 1 502 |
| Textiles . . . . . . . . | 629.7 | 84 | 12 | 96 | 1 234 |
| Chemicals . . . . . . . | 284.5 | 194 | 160 | 354 | 1 292 |
| Paper . . . . . . . . . | 134.0 | 167 | 110 | 277 | 505 |
| Others. . . . . . . . . | 656.0 | 158 | 9 | 167 | 1 751 |
| Total . . . . . . . | 2 941.9 | | | 220 | 9 417 |

*Source: The Economic Development of Brazil, op. cit.,* table 119.

rate was utilized, despite the fact that it is acceptable only in a hypothesis of reduced growth, since no allowance is made for an increase in public lighting services through their extension to urban centres without these facilities. In 1950 about 11 per cent of the municipal districts were in this situation.

### 5. *Commerce*

The growth of electric energy consumption in commerce was projected on the basis of the tendency apparent in several cities served by one of the larger power companies. This tendency is reflected in an annual growth rate of 9.4 per cent.

### 6. *Household lighting*

Here again the historic rate of over-all growth was used, which was known for some large cities. This annual growth rate stood at 13.6 per cent and was accepted as a fist approximation.

### 7. *Summary*

The projection for the electric energy sector as a whole is shown in table 14. According to this, electric energy consumption should grow at an annual rate of 10.3 per cent, which is slightly higher than the 9.6 per cent rate recorded between 1939 and 1949.

The study then compares the results obtained with those derived from other studies made for the same purpose (see table 15).

**Table 14**

CASE 4. PROJECTION OF ELECTRIC ENERGY DEMAND IN BRAZIL

*(Millions of kWh)*

| | *1949* | *1962* | *Percentage increase* |
|---|---|---|---|
| Industries | 2 941.9 | 9 417.0 | 220.1 |
| Transport | 448.2 | 1 100.0 | 145.4 |
| Railways | 313.9 | 723.0 | 154.4 |
| Urban | 134.3 | 377.0 | 123.4 |
| Public lighting | 373.0 | 718.8 | 92.7 |
| Commerce | 536.3 | 1 719.4 | 220.6 |
| Household lighting (capitals) | 1 455.5 | 7 638.5 | 424.8 |
| Unspecified | 482.3 | 1 726.2 | 257.9 |
| Total | 6 237.2 | 22 320.3 | 257.9 |

*Source: The Economic Development of Brazil, op. cit.,* table 120.

*Case 5*

## PROJECTION OF REQUIREMENTS FOR THE SUPPLY OF ENERGY[15]

### 1. *Outline of methods used*

A summary follows of the methods used to project total demand for electric energy in the Latin American countries. The methods of procedure are examples of the combined application of criteria to the projection of electricity demand.

In essence, the method lay in making a projection of total electricity production expressed in kWh, considering simultaneously the international correlations, the product-elasticity,[16] unit consumption per unit of product, over-all historic growth trends, *per capita* consumption, consumption per man employed in industry and the electrification coefficient.[17] The method therefore implies not only a projection of the population and of the gross national product, but also of other energy consumptions. The method followed in the case of Colombia is set out below.

### 2. *Projection of total energy*

First of all, projection of total net energy consumption in Colombia was discussed.[18] It was seen from the historic series of total net energy consumption per unit of product that the long-term trend was downward, except for the last few years, when a sharp recovery was noted.

The analysis of the correlation between total energy consumption and the gross national product, taking countries with different incomes and structural characteristics, reveals that Colombia falls below the energy consumption corresponding to its present level of income. It was also

[15] See *Energy in Latin America* (E/CN.12/384/Rev.1), United Nations publication, Sales No. 1957.II.G.2. The study covers all forms of energy used. The methods employed have therefore been conceived from the standpoint of programming the entire energy sector of the economy. It is as well to remember the fact that the study points out that these are only provisional results. It was an attempt to contribute towards a preliminary approach to the possibilities of energy development in Latin America, not one of making final projections for the preparation of specific projects.

[16] This is the concept, already explained, of income-elasticity applied in terms of the gross national product.

[17] The electrification coefficient computed is used to express the proportion of electric energy within the consumption of all other forms of energy. This last consumption is expressed in tons of "petroleum equivalent", by reducing all other forms of energy consumption to their equivalent in petroleum. The electrification coefficient is therefore defined as the number of kWh consumed for each kilogramme of petroleum, and is the total equivalent of all other forms of energy.

[18] Net losses in transmission and distribution.

**Table 15**

CASE 4. COMPARISON BETWEEN THREE PROJECTIONS OF ELECTRIC ENERGY DEMAND IN BRAZIL

*(Millions of kWh)*

| | *1949* | *1962* | *Percentage increase* | *Annual rate of growth* |
|---|---|---|---|---|
| Extrapolation of 1939-49 tendency | 6 237.2 | 20 589.0 | 230.1 | 9.6 |
| National electrification plan | 6 237.2 | 19 740.0 | 216.5 | 9.3 |
| Hypothesis used in this study | 6 237.2 | 22 320.0 | 257.9 | 10.3 |

*Source: The Economic Development of Brazil, op. cit.,* table 121.

seen that the country's position in the international picture was very close to the substantial change in the ratio of net energy consumption to gross product, which takes place when a country reaches 250 dollars per inhabitant. Once that approximate level has been reached, there are greater possibilities for increasing the rate of industrialization, and within industries there are greater prospects for those branches requiring higher inputs per unit of production, counteracting the decline in unit consumption resulting from increased efficiency in the use of energy.

It was also considered that the greater degree of economic integration—which is now being achieved—will also mean a greater interchange of goods between the various zones of the country; this will result in an increase in the relative importance of transport, and hence of the needs for fuel and energy in general.

On the basis of these considerations, total net energy consumption per unit of product was expected to remain fairly constant in the coming years. In 1954, unit energy consumption amounted to 431 tons of petroleum equivalent per million pesos of gross product (at 1950 prices); in 1955 it was 470 tons. It was assumed that the figure for 1965 would be 450 tons, the average value of 1954 and 1955, adopted because the 1955 ratio was accidentally high, owing to the decline in the gross product that year.

On the assumption that by 1965 the *per capita* product would increase by 25 per cent—that is a total of 14 115 million pesos at 1950 prices—the country's total energy supply requirements would be 14 115 × 450, that is 6.35 million tons of petroleum equivalent. The simple extrapolation of the historic trend would have led to a considerably lower estimate, of only 4.5 million tons of petroleum equivalent. Nevertheless, the previous projection does not seem exaggerated when it is remembered that, according to its new level of income, Colombia would be 28 per cent below the theoretical consumption indicated by the international correlation.

### 3. *Projection of electricity consumption*

During the period 1934-54, electricity consumption in Colombia rose at an average cumulative rate of 10.8 per cent a year, and between 1948 and 1954 at the rate of 13.5 per cent. This also meant a broad improvement in electric energy production per unit of product, the ratio increasing at a rate of over 7 per cent annually between 1934 and 1954.

As for the international correlation, Colombia's electricity consumption during the period 1949-51 was 2.3 per cent below the theoretical consumption according to its level of income, taking into account the average ratio recorded for the other countries.

To make the demand projection, the basis of discussion used was the study made by the National Electrification Plan, and the general results and methods used are set forth below.

The National Electrification Plan for Colombia made the demand projection by three different methods:

(i) *By the rate of aggregate increase.* For the next 16 years the increase would be at the same rate as during the past 15 years (11.1 per cent), that is, doubling in 6.5 years.

(ii) *By income-elasticity.* The following reasoning was used: between 1938 and 1953, for each 1 per cent of increase in the gross national product, there was 3.6 per cent increase in the annual generating of energy. Admitting that national income would rise by 80 per cent between 1950 and 1962 and using the same income-elasticity coefficient of 3.6, energy generating would increase by 288 per cent during the same period, which corresponds to an annual rate of 11.7 per cent (which is the equivalent of doubling every 6.25 years).

(iii) *By* per capita *consumptions estimated in comparison with other countries.* The projection was also made on the basis of *per capita* electric energy consumption, comparing it with other Latin American countries and considering average *per capita* annual income and the population increase. This alternative projection was justified on the basis that in many parts of the country supply was not limited by demand but by the means of production; hence estimates based on the historic series might be inadequate.

It was estimated that by 1954, consumption—if not reduced by supply limitations—would be 300 kWh per inhabitant in urban and 100 kWh in rural areas, with a national average of 160 kWh per inhabitant as against a real consumption of 115 kWh in 1953. Beginning with the assumed consumption for 1953 and assuming that by 1970 all the urban population and half of the rural would be supplied, the annual rate of increase amounts to 13.1 per cent (doubling every 5.5 years).

In brief, then, this leads to the projection shown in table 16 for the years 1965 and 1970.

In the National Electrification Plan it was deduced that the annual consumption in 1970 would be some 10 000 million kWh, with a probable maximum of 11 500 and a minimum of 8 000. Additional studies indicate that to meet average projected demand, the installed capacities ought to be 900 000 kW in 1960, 1 500 000 kW in 1965 and 2 400 000 kW in 1970. On the basis of an effective capacity of 338 000 kW in 1954, the rate of growth of annual installed capacity ought to be some 95 000 kW between 1954 and 1960, 120 000 kW between 1960 and 1965 and 180 000 kW between 1965 and 1970.

The above projections imply a higher rate of growth of Colombian economy compared with that calculated in ECLA's illustrative study. Hence the estimates of electric energy requirements were rounded out in that study to 6 600 million kWh for 1965.

It should be pointed out that both the Technical Mission's projections and those adopted by ECLA appear to be relatively high, particularly if they are judged in the light of international comparisons. In fact, the relationship between electricity consumption and gross product would be quite considerably above the average ratio recorded for other countries. Nevertheless, it is considered within accessible limits. *Per capita* production would amount to some 420 kWh (as against only 166 in 1935), a figure similar to that recorded in 1950 in Italy and Denmark, but much

**Table 16**

CASE 5. SUMMARY OF THE PROJECTION OF ELECTRIC ENERGY CONSUMPTION

| | *Cumulative percentage rate of increase* | *Energy consumption* 1965 | 1970 |
|---|---|---|---|
| | | *(Thousands of millions of kWh)* | |
| According to (i) . . | 11.1 | 6.35 | 8.7 |
| According to (ii) . . | 11.7 | 6.80 | 9.5 |
| According to (iii) . . | 13.1 | 7.01 | 11.2 |

higher than that for Uruguay, which has a present level of *per capita* income similar to that projected for Colombia.

Another indication of the relatively high level of the projections lies in the amount of the electrification coefficient that they imply. By 1965 this coefficient would amount to 0.949, as against only 0.460 in 1954; hence, it is higher than those that the Latin American countries would have if their product should grow at similar rates. The coefficient approaches those of the world's most highly electrified countries in 1950.

Briefly, then, the projections adopted are considered to be indicative of maximum levels and should be adjusted according to a more exhaustive balance of the investment possibilities and distribution.

After projecting other energy requirements, a final table was obtained, the part corresponding to net consumption being reproduced here (see table 17).

### *Case 6*

### Preliminary study of tractor demand

The case below corresponds to a study made for the Chilean Agricultural and Transport Development Plan (*Plan de Desarrollo Agrícola y de Transportes en Chile*). This time it was not made from the point of view of a project to install an assembly industry or for the integral manufacture of tractors in the country, but rather for the balance-of-payments projection used in formulating the Plan. The same figures will naturally serve as a first estimate on the order of magnitude of the national market for these capital goods, and it is being used in that sense. Details that might vary from one country to another are omitted, in order to stress simply the method followed.

**Table 17**

CASE 5. PROJECTION OF ENERGY CONSUMPTION IN COLOMBIA FOR 1965[a]

*(Thousands of tons of petroleum equivalent)*

| | Net consumption | |
|---|---|---|
| | *1954* | *1965* |
| Petroleum derivatives and natural gas | 1 630 | 3 500 |
| Mineral coal and coke | 787 | 1 880 |
| Vegetable fuels | 1 360 | 1 120 |
| Hydroelectricity[c] and[d] | 88 | 340 |
| Thermo-electricity[c] | 43 | 110 |
| Fuels for generating thermo-electricity | —265 | —600 |
| Total energy | *3 643* | *6 350* |
| Consumption of fuels as such | 3 512 | 5 900 |
| Petroleum derivatives: | | |
| Light | 885 | 1 810 |
| Heavy | 745 | 1 690 |
| Electrification coefficient (kWh/kg of petroleum) | 0.464 | 0.919 |

*Source: Energy in Latin America, op. cit.,* Appendix XIII, table 9.

[a] Assuming a *per capita* increase of 2.5 per cent in the gross national product as from 1954.

[b] Petroleum of 10 700 cal/kg.

[c] It is estimated that in 1965 losses will represent 15 per cent of total production.

[d] For 1954 an average of 4 500 calories has been calculated to generate 1 kWh and for 1965 one of 4 000 calories.

#### 1. *Basis of projection*

The basis used was the total number of tractors imported into the country between 1939 and 1953 inclusive, subtracting from this amount those which have finished their useful life (calculated at 10 years according to a previous survey) and those not used in agricultural work. Hence it was concluded that at the time of the study there were 10 400 tractors working in Chilean fields. It may be observed that in the absence of an agricultural census or of direct statistical information, an indirect estimate had to be made. As the import figures recorded statistically make no difference between agricultural and non-agricultural tractors, an additional estimate had to be made concerning the number of the former.

#### 2. *Projection*

The projection was made according to the results shown in table 18.

Column B of the table indicates the number of tractors that completed their useful life each year, according to the import statistics for previous years. Column C refers to tractor demand derived from increases in the area under cultivation, in accordance with the objectives of the Agricultural Development Plan. Column D refers to demand derived from a higher degree of mechanization, that is, from the substitution of other forms of traction—differing from that achieved with tractors—and has also been estimated in terms of the Plan's objectives. Column E represents total annual demand.

Average annual demand for the different periods would be the following:

| *Periods* | *Tractors per year* |
|---|---|
| 1954-57 | 1 400 |
| 1958-61 | 2 337 |
| 1954-61 | 1 868 |

The corresponding average annual imports were:

| *Periods* | *Tractors per year* |
|---|---|
| 1946-53 | 1 276 |
| 1949-53 | 1 438 |

The figures in the last column of table 18 reflect the upward trend in the demand component represented by replacement. It can also be seen that the growth in the replacement percentage is not uniform, as shown by the demand points in columns B and E. This is due to irregularity in the historic series of tractor imports, undoubtedly affected by the war. That is why, in spite of an assumed future uniform growth of agricultural production, peak demands are recorded in some years of the projection period.

#### 3. *Other data*

The market study for tractors cannot be confined to obtaining the figures indicated in table 18. Other data must also be known, such as those relating to trading and technical services, for instance. In the annex on agricultural mechanization, the Plan explains that in 1950 the *Corporación de Fomento* undertook a survey designed to discover various features of the market. Some of them are given below.

The average tractor in Chile is of 32.3 h.p. at the trac-

Table 18

CASE 6. PROJECTION OF TOTAL DEMAND FOR TRACTORS

| Year | Tractors in use (A) | Annual demand for tractors: For replacement (B) | Through increases in the cultivated area (C) | Through improved mechanization (D) | Annual total (E) | Percentage of replacements within total demand (100 B/E) |
|---|---|---|---|---|---|---|
| 1954 . . . . . | 10 400 | 199 | 820 | 156 | 1 175 | 17 |
| 1955 . . . . . | 11 376 | 482 | 652 | 156 | 1 290 | 37 |
| 1956 . . . . . | 12 184 | 761 | 701 | 156 | 1 618 | 47 |
| 1957 . . . . . | 13 041 | 560 | 799 | 156 | 1 515 | 37 |
| 1958 . . . . . | 13 996 | 1 703 | 809 | 156 | 2 668 | 64 |
| 1959 . . . . . | 14 961 | 1 157 | 785 | 156 | 2 098 | 56 |
| 1960 . . . . . | 15 902 | 775 | 796 | 156 | 1 727 | 45 |
| 1961 . . . . . | 16 854 | 1 915 | 784 | 156 | 2 855 | 67 |
| 1962 . . . . . | 17 794 | | | | | |

*Source:* Development Corporation *(Corporación de Fomento de la Producción)* Chilean Agricultural and Transport Development Plan, 1954.

tion bar and replaces or is equivalent to 24 traction units.[19] These equivalences make it possible to estimate that the number of tractors needed for total mechanization of the country's cultivated area would be 26 000. Another calculation, carried out on the basis of farm sizes, reached a similar figure (almost 27 000). Approximately 1 tractor is used for every 100 hectares under cultivation, a ratio which can be used as an index of the degree of mechanization. On the basis of this index the additional demand for tractors can be calculated when an increased degree of mechanization is attempted.

### *Case 7*

### Preliminary estimate of demand for rails[20]

This case has been taken from the appendix on transport included in the study on *The Economic Development of Brazil.*[21] It is not a formal market study, but an example of a preliminary estimate that could be used in a preliminary project. First of all an estimate was made of the number of rails that the railways would require each year to meet their normal replacement needs.

The calculation was based on two guiding principles: the number of rails at present in use, and the estimated life of such materials. As no authoritative information existed on the latter point, it was considered advisable to base the projection on more than one hypothesis. The information available led to an estimate of 2.2 million tons for the weight of rails in all the existing lines used for traffic. (A table was given indicating the length of the tracks, the type of rail and weight for each type of track: for 10 per cent of the tracks there was no exact information and reliance had to be placed on estimates.) The weight of rails on sidings, shunting lines, etc., was not included, since such rails are often those discarded from main and branch lines.

The average useful life of the rails on any section is a function of three variables, i.e., the type of rail, the density of traffic and the number, length and radius of the curves. Since adequate data on average life are not available, it was decided to project rail requirements on age limits of 30 and 40 years, based on the views of railway experts. On this basis, if the type of rail in use does not change, about 55 000 to 73 000 tons would be required to cover normal annual replacement needs, depending on the hypothesis adopted relating to useful life. As there are reasons for assuming that the average weight should increase (it is at present 29 kilogrammes per metre and could rise to 37), the demand for replacement rails would range from 70 000 to 93 000 tons.

Taking into account, in addition, construction of new lines at the rate of 175 kilometres a year, at an average weight of 37 kilogrammes per metre, a demand of nearly 13 000 tons would be added, bringing total rail requirements to between 83 000 and 106 000 tons *per annum.* This estimate, according to a footnote, excludes requirements arising from lack of replacements; 580 000 tons of rails are needed to meet this deficit.

### *Case 8*

### Market study for a cement plant project

This example has been taken from the project to erect a cement plant at Pacasmayo, Peru. The company is a private one and obtained partial financing from the International Bank.[22]

In the summary which follows it can be clearly seen that there is a simultaneous approach to problems of the amount and localization of demand, on the one hand, and to production costs and selling prices, on the other.[23]

#### 1. *Amount and localization of demand*

Over the past two years it has become apparent that there is a demand for cement which is insufficiently met by local production. Even by resorting to imports, some

[19] The traction unit is a horse or its equivalent in oxen.
[20] This footnote refers to the Spanish text only.
[21] *Op. cit.*, pp. 131-132.

[22] See separate examples on the description and investments in the project (case 31) and on the manner in which some financial aspects are analysed and presented (case 42).
[23] The figures quoted are estimates of the preliminary study, so that they do not necessarily reflect the present situation.

projects are delayed by cement shortages. There is a nominal market price for the product, but the real price is higher in many areas, the overprice ranging from 11 to 33 per cent. This overprice mainly affects the small consumer.

For a long time cement consumption has been growing at an annual rate of 8.5 per cent—a trend which, if it persists, would bring consumption up to 650 000 tons in 1958—but in recent years real consumption has grown at even higher rates. Present installed capacity is 520 000 tons *per annum* in the plants at Lima and Chilca.

Because of the upward trend of consumption, the Pecasmayo plant will be insufficient to meet the growth in demand or to confine cement imports to a reasonable minimum. A consumption of 500 000 tons growing at a rate of 8 per cent means an increase in demand of 40 000 tons a year, so that apart from the Pecasmayo plant, it will be necessary to plan the expansion of cement productive capacity in Peru. Statistical figures reveal that nearly 8 000 tons were imported in 1951, 56 000 in 1952, 90 000 in 1953 and 30 000 in 1954. Imports of cement in amounts equal to the proposed plant's output, mean burdening the balance of payments by some 3 million dollars per year.

The new factory is intended to supply the market on the country's northern coast (from Chimbote to the north, as far as the frontier with Ecuador). This zone contains some of the principal farming and mining regions in Peru.

The development of total consumption in the northern zone can be seen from table 19. The destination of the cement consumed in the zone is shown in table 20.

On the basis of these figures, it is estimated that the cement market in the northern zone will be some 150 000 tons a year by the time the Pacasmayo factory is built.[24] Hence there seems to be a reasonable certainty that demand in northern Peru would shortly permit the proposed plant to function to its full capacity with an annual output of 100 000 tons. The figures also show that cement production in the northern part of Peru, as regards the satisfaction of local markets, will not seriously prejudice the market of the existing enterprises.

[24] The projection of demand was made by extrapolating an adjustment curve for a historic series of 17 years referring to cement consumption in the north.

**Table 19**

CASE 8. CEMENT CONSUMPTION IN THE NORTHERN ZONE

| *Year* | *Thousands of tons* |
|---|---|
| 1948 | 36 |
| 1949 | 39 |
| 1950 | 59 |
| 1951 | 65 |
| 1952 | 90 |
| 1953 | 145 |
| 1954 | 134 |

**Table 20**

CASE 8. CEMENT UTILIZATION IN THE NORTHERN ZONE

*(Tons)*

| | *1952* | *1953* | *1954* |
|---|---|---|---|
| Government projects | 34 000 | 55 000 | 50 000 |
| Oilfields | — | 3 000 | 3 000 |
| Private building | 56 000 | 87 000 | 81 000 |

*2. Production costs and prices*

It should also be remembered that the saving in freight should permit the consumer to obtain the cement at a lower price than at present, according to the estimated production costs indicated in table 21. These production costs are considered reasonable and compare favourably with similar costs in Lima and in the United States.

Cement imported from Japan costs 28 dollars per ton (560 soles) and from the United Kingdom 33 dollars (660 soles), excluding customs duties, calculated at some 70 soles per ton. Table 21 shows that the enterprise, in its own zone, would be operating under favourable price conditions.

Comparing the prices of cement produced in Lima when it reaches the north of Peru, it appears that although these are rather high, they are still lower than those for imported cement. Selling prices in the northern cities range from 505 to 788 soles per ton as against 338 in Lima. The very high cost of freight and distribution is due to the fact that most of it is done by lorry, because cement arrives in better condition and there is less loss than when the sea route is used.

A table was presented comparing probable selling prices for the cement produced in Pacasmayo with those for cement from Lima in various northern cities. Taking the cost of production as a basis, probable selling prices were adopted of 360 and 400 soles per ton, placed at the factory, and to this price was added the freight to different points

**Table 21**

CASE 8. ESTIMATED PRODUCTION COST OF FINISHED CEMENT

*(Soles per ton)*

| | |
|---|---|
| *Direct cost:* | |
| *Raw materials:* | |
| Limestone | 28.88 |
| Slate | 3.41 |
| Gypsum | 3.29 |
| | 35.58 |
| *Manufacture:* | |
| Direct labour | 4.02 |
| Fuel | 41.46 |
| Electric energy | 13.35 |
| Sacks | 39.39 |
| | 98.82 |
| *Total direct cost* | 134.40 |
| *Indirect cost:* | |
| Administration and sales | 7.22 |
| Social benefits and taxes on salaries | 3.03 |
| Insurance and other items | 4.60 |
| Indirect labour, excluding maintenance | 6.60 |
| Maintenance (labour and material) | 30.55 |
| | 52.00 |
| *Depreciation* (linear) | 40.68 |
| Total excluding interest | 277.08 |
| Interest payments | 23.41 |
| *Grand total* | 250.49 |

in order to estimate the competitive position in relation to cement from Lima. The same was done for cement from Lima, and the final results are shown in table 22. The figures in the table indicate that, within the proposed factory's zone of influence, it could operate under very favourable competitive conditions.

### *Case 9*

### Influence of economic policy in the development of the Australian road vehicle industry[25]

A specific example of the incidence of political economy on the development of an industry is provided by the case of motor vehicles manufacture in Australia.

The incentive to car production in Australia began in 1917, when restrictions were introduced on imports of motor vehicle bodies because of the space limitations in ships supplying the country from abroad. It was ruled that 2 out of every 3 cars had to be imported without body work. In 1921 this system was replaced by a protective tariff for industries set up as a result of the above legislation. In addition, the import tax on the chassis was raised, while a low rate was left for vehicles arriving in knocked down condition, in order to encourage assembly in Australia. In this way the industry prospered rapidly and passed from the body-building stage to that of chassis assembly. In 1925 the Canadian Ford company put up assembly shops, followed in 1926 by General Motors. In 1935-39, of an annual registry of over 50 000 vehicles, only 2 000 or 3 000 were units imported complete.

Protectionist policy was used flexibly to permit supplying the accumulated unsatisfied demand which grew up as a result of the war. Table 23 shows the development of the market from 1937 to 1951 and permits an appreciation of the sharp increase in imports of complete units during the period 1949-51.

On their own initiative, most of the assembly shops which started up in Australia tended to use growing proportions of parts made locally. The Government policy was directed towards leaving the assembly shops free concerning the replacement of imported material; there was no attempt to impose specific quotas, but replacement was induced by indirect measures.

In 1936 the Government indicated that it would strongly encourage the establishment of engine production in Australia. In 1939 a law was passed granting a subsidy of thirty pounds for every engine produced. Plans were shelved during the war, and in 1945 the subsidy legislation was revoked.

A new policy began in 1944. The prime minister publicly invited the motor vehicle manufacturers to send in their plans for making the entire vehicle in Australia. A series of proposals was received from United States and British manufacturers operating on the Australian market. The incentive legislation included, among others, the following regulations: (*a*) the machinery and some components would be subject to customs concessions; (*b*) the companies would be assisted in solving their exchange problems; (*c*) plant and equipment would be exempted from sales tax; (*d*) an income tax reduction would be granted by means of regulations relating to depreciation; and (*e*) foreign specialists and technicians would be exempt from income tax.

Government measures also affected financing. In fact, enterprises which wished to obtain capital exceeding a certain amount by means of share issues, had to obtain the consent of the Commonwealth treasury, a regulation inspired by the desire to channel investments towards high priority defence projects.

As a result of this policy the number of engines of domestic production increased considerably, as shown in table 24.

Also as a result of the policy described, the four main

[25] Taken from the visit of the Brazilian Automotive Sub-Committee to Ford Motor Company, *op. cit.*

**Table 22**

CASE 8. COMPARISON OF CEMENT PRICES IN SELECTED CITIES

*(Soles)*

| City | Price of Pacasmayo cement | Price of Lima cement | Prices of imported cement |
|---|---|---|---|
| Pacasmayo . . . | 360.00 | 400.00 | 443.82 |
| Trujillo . . . . | 381.20 | 421.20 | 432.06 |
| Chimbote . . . | 407.20 | 447.20 | 408.52 |
| Chiclayo . . . . | 380.80 | 420.80 | 443.82 |
| Piura . . . . . | 435.20 | 475.20 | 514.38 |
| Sullana . . . . | 443.00 | 483.50 | 514.38 |
| Talara . . . . | 461.80 | 501.80 | 454.39 |
| Tumbes . . . . | 495.40 | 535.40 | 573.18 |
| Cajamarca . . . | 438.80 | 478.80 | 573.18 |
| Juen. . . . . . | 528.00 | 568.00 | 713.00 |

**Table 23**

CASE 9. REGISTRATION AND ANNUAL IMPORTS OF VEHICLES IN AUSTRALIA

*(Thousands of units)*

| Year (as of 30 June) | Imports of unassembled chassis (A) | Imports of complete units (B) | Annual registry of vehicles (C) | Percentage of B over C |
|---|---|---|---|---|
| 1937. . . . | 69 | 3 | 73 | 4 |
| 1938. . . . | 88 | 3 | 83 | 4 |
| 1939. . . . | 75 | 2 | 79 | 3 |
| 1940. . . . | 66 | 1 | 60 | 2 |
| 1941. . . . | 30 | 1 | 28 | 4 |
| 1946. . . . | 10 | 5 | 9 | 56 |
| 1947. . . . | 66 | 1 | 38 | 3 |
| 1948. . . . | 56 | 11 | 72 | 15 |
| 1949. . . . | 71 | 31 | 103 | 30 |
| 1950. . . . | 86 | 103 | 173 | 60 |
| 1951. . . . | 12 | 75 | 206 | 36 |

*Source*: Report on the visit of a Brazilian technical mission to the Ford Company.

**Table 24**

CASE 9. AUSTRALIAN PRODUCTION OF INTERNAL COMBUSTION ENGINES AND BODIES

*(Thousands of units)*

| Year (as of 30 June) | Engines | Bodies |
|---|---|---|
| 1938. . . . . . . . | 2.8 | 59.4 |
| 1949. . . . . . . . | 26.0 | 41.0 |
| 1950. . . . . . . . | 27.9 | 48.2 |
| 1951. . . . . . . . | 31.0 | 62.3 |
| 1952. . . . . . . . | 30.7 | 68.8 |

enterprises operating on the market progressively increased the utilization of local labour and that of locally manufactured parts.

*Case 10*

### The development of the motor vehicle industry in Brazil

In the following example, a description will be given of the main lines along which Brazil's motor vehicle industry has developed. The description has been divided into two parts. The first will deal with the Government policy which was adopted to encourage private industry to develop this branch of production and its successful implementation. The second will explain the methods selected for studying the lorry market.[26]

#### 1. *The policy of incentive*

The first measures to stimulate production of motor vehicles in Brazil were adopted by the Export and Import Department (*Carteira de Exportação e Importação*, CEXIM).[27] It was decided, in October 1952, to restrict the issue of import licences for the purchase of motor vehicle parts to those that could not be manufactured domestically; the number of items prohibited amounted to 104, and a effective safeguard and powerful stimulus was thereby created for domestic manufacturers. Brazil's production of spare parts boomed and became an important factor when a motor vehicle policy was formulated and finally took shape in 1956, as will be discussed later.

In 1952, studies were also undertaken by the Sub-Commission on jeeps, tractors, lorries and motor cars (*Subcomissão de jeeps, tratores, caminhões e automoveis*), which is subordinate to the National Commission for Industrial Development (*Comissão Nacional do Desenvolvimento Industrial*). By virtue of the first recommendations made by the Sub-Commission, imports of motor vehicles already assembled were banned by CEXIM from 1953 onwards, and licences were granted only for vehicles to be assembled in Brazil. The Sub-Commission also recommended that an executive committee be set up in the industry manufacturing motor vehicle parts; this was established under the name of CEIMA in the Ministry of Finance in June 1954, but proved unsatisfactory for internal reasons.

The process of formulating a policy to encourage the domestic motor vehicle industry was begun again in March 1956 with new provisions laid down by the Department of Currency and Credit. These were intended to limit imports of unassembled vehicles and accessories and to establish fixed stages of nationalization for factories and assembly-plants in accordance with plans to be reviewed by the industrial advisory board of the Government's Foreign Trade Department (*Carteira de Comercio Exterior*, CACEX).

These provisions were generally found difficult to comply with and did not lead to the anticipated results.

In April 1956, a Working Group was set up in the Development Council (*Conselho do Desenvolvimento*)—which is responsible for preparing economic development programmes—in order to study and propose the most desirable Government policy for the establishment of a national motor vehicle industry.

The Working Group made use of all the previous data and studies on the subject and submitted its conclusions so rapidly that, by mid-1956, a decree was promulgated establishing criteria for the development of the industry, and setting up an Executive Group for the Motor Vehicle Industry (GEIA), as a subsidiary body of the Development Council.

The basic criteria which were set forth by the group to justify the adoption of a policy to stimulate the establishment of a domestic motor vehicle industry are reproduced here, together with summary of the main lines of the policy.

The reasons adduced for setting up the industry were based on the following factors:

(*a*) The market is large enough to maintain a domestic industry with a reasonable economic basis. The method used in studying the market will be explained later.

(*b*) The industrial infrastructure is fairly well developed and large enough to meet the raw material requirements of the motor vehicle industry.

(*c*) Brazil already has factories that can supply motor vehicle manufacturers with various parts and accessories, and several projects with the same objective are under way.

(*d*) The industry will probably have a large margin of profit, to judge by the prospects for domestic manufacturing costs and prevailing market prices.

(*e*) The alternative of importing motor vehicles, which was followed up to 1945 by representative or branch agencies of foreign producers, does not give these agencies in Brazil an adequate or sufficiently attractive volume of business.

(*f*) There is little to be feared from the competition of imported vehicles since price prospects are encouraging as a result of Brazil's exchange situation.

In connexion with its policy to promote the establishment of a motor vehicle industry, the Government should bear in mind the following points:

(*a*) The statement of policy should be clear and explicit

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[26] The sources of information used were pamphlets Nos. 9, 10, 11 and 12 of the series *"Un plano en marcha"* published by the Ministry of Transport and Public Works (*Ministério de Viação e Obras Públicas*), entitled: *Aspectos Econômicos da Fabricação de Automóveis no Brasil* (Economic aspects of motor vehicle manufacture in Brazil); *Relátorio do Grupo de Trabalho sôbre Indústria Automobilística* (Report of the Working Group on the Motor Vehicle Industry); *Legislação Relativa à Indústria Automobilística* (Legislation on the motor vehicle industry); and *Relátorio das Atividades do GEIA* (Report on the activities of the GEIA); Documents Service (*Serviço de Documentação*), Rio de Janeiro, 1957.

Reference was also made to the report of the Latin American Group of Experts on the Steel Making and Transforming Industries, entitled: Problems of the steel making and transforming industries in Latin America (E/CN.12/425 and Add.1), United Nations publication, Sales No.: 1957.II.G.6, Vol. I. In addition, first-hand information was supplied by Mr. Sidney Latini of the Economic Development Bank (*Banco do Desenvolvimento Econômico do Brasil*), and by members of the Executive Group for the Motor Vehicle industry (GEIA).

[27] CEXIM, which disappeared in October 1953, used to be a Government agency of the *Banco do Brasil* and was responsible for granting import licences and maintaining quantitative restrictions on all foreign trade. It was replaced by CACEX, also a department of the *Banco do Brasil*. CACEX registers external trade transactions paid at fluctuating exchange rates and checks the prices quoted for the merchandise. It also supervises foreign investment negotiations in Brazil that require no exchange cover from domestic availabilities. In addition, the *Banco do Brasil* executes the monetary policies drawn up by the Department of Currency and Credit (*Superintendência da Moeda e Crédito, SUMOC*).

in order to convince interested parties of its stability, without at the same time being too inflexible.

(*b*) The best way in which to deal with point (*a*) would be to set forth the policy in a governmental decree.

(*c*) The policy should clearly indicate the exchange treatment to be applied to the motor vehicle industry, based on the economic level of the respective products, the type of entrepreneur involved in the different projects and the margin of capital invested in the latter.

(*d*) The principles established should be put into practice by a central organization which would co-ordinate all the administrative units working in the field (SUMOC, CACEX, etc.).

(*e*) The principles should be applied with exemplary firmness.

CEIA wields all the executive power relating to regulation supervision and control of activities connected with motor vehicles manufacture. It was explicitly laid down that GEIA should confine itself to guiding and co-ordinating different enterprises so as to make them mutually comparable, the industry being otherwise reserved entirely for private enterprise. GEIA was also intended to ensure that the different enterprises had a sound technical and economic basis and to reconcile their exchange requirements with Brazil's possibilities.

Government action would be essentially indirect through the granting of preferential exchange treatment for imports of capital equipment and component parts to be assembled in Brazil. An Act which became law in December 1956 also exempted imports of capital equipment for manufacturing motor vehicles and internal combustion engines from customs duties.

Lastly, credit facilities were provided as incentives for what were termed "basic industries", i.e., those resulting from projects for the motor vehicle industry that had been approved by GEIA. This classification would help in the obtaining of credits or guarantees from development banks, or in the soliciting of foreign loans.

The policy advocates the practice of intensive sub-contracting, i.e., of a horizontal industrial structure. For this purpose, the GEIA regulations divided factories into two categories: those manufacturing vehicles and those turning out spare parts and accessories. In order to claim the benefits mentioned above, motor vehicle manufacturers would have to comply with the following requirements:

(*a*) Their over-all production projects would have to be approved by GEIA;

(*b*) They should submit specific projects including engine manufacture either in their own plants or by sub-contractors; and

(*c*) Their work programmes should provide for the gradual replacement of imports by domestic parts, in accordance with the percentages laid down in the projects.

Sub-contractors to manufacturers of spare parts or motor vehicles were those whose projects had been approved by GEIA and whose output consisted wholly or partially of specific parts for vehicles.

In relation to the participation of foreign and Brazilian enterprises, the policy is to encourage foreign companies to set up assembly activities while the Brazilian firms concentrate on making spares and accessories.[28]

One fundamental aspect of Brazil's policy for the motor vehicle industry was the establishment of a fixed number of stages to ensure that the production of spare parts would be progressively nationalized. With this in mind, assembly plants were directed to use an ever-increasing proportion of domestic components, which in the short space of five years, would enable them to reach a low coefficient of foreign exchange dependence. Over-all annual requirements of foreign exchange arising out of production programmes were estimated on this basis. The programme implementation for the successive stages is given in table 25.

The legislation summarized previously was set forth in four decrees (one for each type of vehicle on the dates indicated in table 25) and an Act (dealing with exemption from customs duties). Results were swiftly obtained. Under the stimulus of this legislation, the *Fábrica Nacional de Motores* (Alfa-Romeo lorries) and *Mercedes Benz do Brasil* brought their respective lorry programmes into line with the national plan for the motor vehicle industry; General Motors and Ford decided to make large-scale investments to transform their old-fashioned assembly plants into modern factories capable of manufacturing engines as well. Willys-Overland and Vemag-DKW set their production targets and speeded up their nationalization indices in order to become eligible for the legal benefits. Finally, Land Rover, Toyota and Fabral obtained approval for projects for the first two to begin jeep manufacture and the third to initiate passenger car production. Little more than a year after GEIA was set up, approved production programmes for motor vehicles were as indicated in table 26.

[28] According to the report by the Latin American Group of Experts on the Steel Making and Transforming Industries, this decision seems to have been based on the fact that: (*a*) "foreign firms have more experience in mass production assembly lines" and "there is greater capital intensity" in "these activities"; and (*b*) "there is already a domestic industry producing parts, which offers a good starting point for the new initiatives needed in this sector, whilst requiring relatively less capital". See *Problems of the steel making and transforming industries in Latin America, op. cit.*, vol. I, p. 25, para. 295).

**Table 25**

CASE 10. ESTIMATED TIME-TABLE OF NATIONALIZATION IN THE BRAZILIAN MOTOR-VEHICLE INDUSTRY

| *Type of vehicle* | *Date of decree on manufacture and incentives* | *Stages of implementation Parts manufactured domestically as a percentage of total weight of vehicle* | | | | |
|---|---|---|---|---|---|---|
| | | *31-12-56* | *1-7-57* | *1-7-58* | *1-7-59* | *1-7-60* |
| Lorries | 12-7-56 | 35 | 40 | 65 | 75 | 90 |
| Jeeps | 12-7-56 | 50 | 60 | 75 | 85 | 95 |
| Station-waggons, light lorries and vans | 30-7-56 | 40 | 50 | 65 | 65 | 90 |
| Passenger cars | 26-2-57 | — | 50 | 65 | 85 | 95 |

**Table 26**

CASE 10. MOTOR-VEHICLE PRODUCTION PROGRAMME IN BRAZIL[a]

*(Number of vehicles)*

| Year | Lorries Total [b] | Jeeps Total [c] | Station-waggons, vans, etc. [d] | Passenger cars Total [e] | Grand total |
|---|---|---|---|---|---|
| 1957 | 20 500 | 10 600 | 6 700 | 800 | 38 600 |
| 1958 | 33 900 | 17 400 | 9 600 | 2 500 | 63 400 |
| 1959 | 56 400 | 21 900 | 12 200 | 8 200 | 98 700 |
| 1960 | 80 300 | 24 000 | 16 200 | 11 500 | 132 000 |
| 1961 | 81 200 | 24 200 | 17 200 | 14 500 | 137 100 |
| *Total* | 272 300 | *98 100* | *61 900* | *37 500* | *469 800* |

[a] Projects approved by GEIA up to 30 September 1957.
[b] General Motors (two types), Ford (two types), Mercedes Benz (three types); *Fábrica Nacional de Motores* (one type).
[c] Willys Overland, Vemag DKW, M.B.A., Rover, Toyota.
[d] Ford F-100, Vemag DKW, Volkswagen-Kombi.
[e] Vemag DKW, Alfa Romeo 102-B, Fabral.

With regard to the manufacture of parts, by 30 September 1957, GEIA had approved 24 projects for such products as pistons, radiators, brake-drums, bearings, cylinder cases, clutch-plates, axles, differentials, valves, connecting-rods, engine-blocks, cylinder-heads, starters, dynamos, gear-boxes, chassis, bodies, electrical equipment such as coils, horns, distributor rotors, relays and voltage regulators, and several other items.

According to estimates made in September 1957,[29] the targets contemplated for the whole group of projects referred to above would require a further 450 million dollars, out of which approximately 190 million would come from foreign sources or the accumulated reserves of the foreign companies operating in Brazil. The remainder would have to be financed by local funds.

Imported equipment would cost about 137 million dollars; the remaining investment would consist of mobile resources in cruzeiros. Part of the imported equipment would represent foreign capital contributions; in the case of motor vehicle manufacture; these investments would amount to over 46 million dollars, or more than 80 per cent of the total sum programmed which is 55 million. Foreign participation in the manufacture of spare parts is estimated at about 17 million dollars. A break-down of total investment required by the programme is given in table 27.

[29] By GEIA.

The following are some of the conclusions which may be drawn from the table:

(*a*) Operation of the industry would require some 280 million dollars of circulating capital out of a total of about 660 million;

(*b*) Total capital needed for the manufacture of spare parts (352 million) would be more than that for motor vehicles (308 million);

(*c*) Both capital already invested and total capital needed for producing spare parts are higher than the corresponding figures for motor vehicle manufacture.

It is estimated that this investment would raise the employment level in the sector programmed from 24 000 to 77 000 persons in little more than three years.

The total weight of the motor vehicles to be produced in 1961 would be some 262 000 tons (2 206 kilogrammes per vehicle) which, taking into account loss of weight in the manufacturing process, represents an aggregate derived demand of about 332 000 tons (2 798 kilogrammes per vehicle). The weight of the spare parts that would be needed for a total vehicle park of 1 100 000 in 1961 is estimated at approximately 194 000 tons (101 kilogrammes per vehicle).

**Table 27**

CASE 10. ESTIMATED STOCK OF CAPITAL AND NEW INVESTMENT REQUIRED FOR THE MOTOR-VEHICLE DEVELOPMENT PROGRAMME IN BRAZIL

*(Millions of dollars)*

| | *Total capital required*[a] | | *Capital already invested* | | *New investment required*[b] | |
|---|---|---|---|---|---|---|
| | *Manufacture of vehicles* | *Manufacture of spare parts and accessories* | *Manufacture of vehicles* | *Manufacture of spare parts and accessories* | *Manufacture of vehicles* | *Manufacture of spare parts and accessories* |
| Capital equipment: | | | | | | |
| Imported | 71.1 | 112.3 | 16.1 | 30.4 | 55.0 | 81.9 |
| Domestic | 9.6 | 22.0 | 3.3 | 9.7 | 6.3 | 12.3 |
| Local services | 7.4 | 9.6 | 6.1 | 4.1 | 1.3 | 5.5 |
| Sites and constructions | 58.9 | 86.2 | 40.0 | 34.9 | 18.9 | 51.3 |
| Total fixed investment | 147.0 | 230.1 | 65.0 | 79.1 | 81.5 | 151.0 |
| Circulating capital | 161.1 | 121.8 | 25.0 | 38.0 | 136.1 | 83.8 |
| Total capital | 308.1 | 351.9 | 90.5 | 117.1 | 217.6 | 234.8 |

[a] Value of installed capacity, plus circulating capital available.
[b] Difference between total capital required and capital already invested.

## 2. *Study of the lorry market*[30]

The study analyses the two components of lorry demand separately: units for increasing the existing park, and replacements for lorries that are unserviceable or worn-out.

### (a) *Total number of lorries estimated*

This estimate was arrived at by extrapolating the rate of growth from the number of existing lorries (including omnibuses). The authors of the study point out that the time series shows four completely different market situations, to wit:

(i) The pre-war period, which was characterized by purchases at a "fair price", since imports were paid for at the real rate of exchange. Between 1930 and 1938, the number of lorries increased at a cumulative annual rate of 6.2 per cent.

(ii) The Second World War, when supplies were scare.

(iii) The post-war period up to mid-1953, when an artificial exchange rate was applied to imports and changes took place in import controls. From 1945 to 1954, the total number of lorries and omnibuses in service increased at an annual cumulative rate of 14.5 per cent.

(iv) The subsequent period, when import costs rose unduly as a result of the exchange measures in force.

The authors draw attention to the fact that a projection of demand must reckon with the possibility that lorries manufactured in Brazil might be sold for less than the market price prevailing at the time of the study. This also limits the validity of the time series as a projection basis.

The annual cumulative rate of growth of 6.2 per cent for the lorry park in 1930-38, which was not affected by unusual prices or deferred demand, was taken as the most representative of the series. In any case, it was moderate in comparison with the post-war rate of 14.5 per cent. The number of lorries in circulation during the following decade (1954-64) was estimated by applying the rate of 6.2 per cent from 1954 onwards, when 352 217 units were in service. On this basis, the lorry park in 1964 was assumed to consist of some 643 000 units. This implies, in other words, that in 1954-64, the Brazilian market could absorb the difference between 643 000 and 352 000, i.e., some 300 000 units, merely as an addition to the park. In order to estimate total market volume, the second component of demand, consisting of replacements for obsolete lorries, should be added to the above-mentioned figure, which represents an annual average of 30 000 units.

### (b) *Demand for replacements*

In order to calculate this component of demand, the project-makers began by determining the useful life of a lorry in Brazil. Since the United States sets the maximum limit at eight years, they have assumed that the same term might be reasonably adopted for Brazil, in view of the following circumstances: (i) Brazilian highways are not as well-paved as their United States counterparts; (*ii*) in Brazil, lorries are often loaded beyond their nominal capacity, which reduces their useful life; (iii) the lower standard of maintenance services in Brazil shortens the normal life of the vehicle; (iv) the only factor which tends to prolong the life of a lorry in Brazil beyond the corresponding figure for the United States is that its annual hours of service are less.

The method used in the study for estimating the age composition of the lorry park is demonstrated in the first place, by a hypothetical table, and thereafter, by specific reference to the case of Brazil. An abstract is given later of the method and its application.

Table 28 contains a model calculation with hypothetical figures; the "stocked" column indicates the numer of vehicles in circulation each year. Stocks in year X should be equal to those of the preceding year plus imports in year X (if it is assumed that there is no domestic production). The figures may fail to tally for two reasons: (i) not all imports are sold; or (ii) some units were taken out of service. The first implies an accumulation of stocks for future sale, and the possibility that in certain years the increase in stocks might exceed imports. Once inventories for specific years are known, the alternatives can be traced for each year, as will be shown later. The second cause is the vehicle's obsolescence for any of several reasons.

It may be observed from table 28 that a "sales" column has been added after those for "stocks" and "imports". If there is any year in the time series in which unsold

[30] Taken from the *Relátorio do Grupo de Trabalho sôbre Indústria Automobilística, op. cit.*

**Table 28**

CASE 10. MODEL FOR CALCULATION TO BE USED IN ANALYSING AGE-COMPOSITION OF THE LORRY PARK IN BRAZIL

| *Year* | | *Imports* | *Sales* | *Age of existing units* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* |
| 1 | — | 3 | — | — | — | — | — | — | — | — | — | — |
| 2 | — | 4 | — | — | — | — | — | — | — | — | — | — |
| 3 | — | 5 | — | — | — | — | — | — | — | — | — | — |
| 4 | 10 | 3 | 3 | 3 | 5 | 2 | — | — | — | — | — | — |
| 5 | 12 | 5 | 5 | 5 | 3 | 4 | — | — | — | — | — | — |
| 6 | 13 | 4 | 4 | 4 | 5 | 3 | 1 | — | — | — | — | — |
| 7 | 16 | 10 | 9 | 9 | 4 | 3 | — | — | — | — | — | — |
| 8 | 20 | 8 | 6 | 6 | 9 | 4 | 1 | — | — | — | — | — |
| 9 | 25 | 2 | 5 | 5 | 6 | 9 | 4 | 1 | — | — | — | — |
| 10 | 24 | 2 | 2 | 2 | 5 | 6 | 9 | 2 | — | — | — | — |
| 11 | 30 | 6 | 6 | 6 | 2 | 5 | 6 | 9 | 2 | — | — | — |
| 12 | 38 | 12 | 11 | 11 | 6 | 2 | 5 | 6 | 8 | — | — | — |
| 13 | 52 | 13 | 14 | 14 | 11 | 6 | 2 | 5 | 6 | 8 | — | — |

stocks were inventoried when stocks were known to be non-existent, subsequent inventories can be calculated on the basis of that year for each of the following years, provided that data are available on stocks, imports and sales.

Taking year 11 in table 28 as an example, when stocks consisted of 30 vehicles, it may be observed that in the twelfth year, 12 vehicles were imported, and that without the intervention of certain factors, stocks should therefore have risen to 42. However, it appears from the table that they were only 38 in that year. The discrepancy of four units between both totals may be explained in the following way: (i) one unit was transferred to inventories, as 12 were imported and only 11 were sold; (ii) the two units which were six years old in the eleventh year did not appear under the heading of "seven years" in the twelfth year, which indicates that they were taken out of service; (iii) out of the nine lorries which were five years old in the eleventh year, only eight continued to the twelfth year (six years old), which implies that one of them was removed from circulation.

The situation in the eighth and ninth years should be studied next. Stocks of 20 vehicles in the eighth year should have increased to 22 by the ninth year in view of the fact that two units were imported in the latter year; however, the table shows that, in practice, stocks were 25, i.e., three more. This is attributable to the fact that although only two were imported, five vehicles were sold, the three remaining units being obtained from the previous year's inventory.

Lastly, it should be noted that lorries sold each year appear in the table as one year old. The column "one year" is therefore equivalent to the "sales" column.

To sum up, once data can be obtained on imports (or domestic production plus imports), sales, the number of vehicles in circulation and age distribution in a given year, estimates can be made as in table 28, of representative age composition at the present time.

In the case reviewed, the calculations covered the period 1930-54 and the resulting percentage age distribution of vehicles is traced in figures as well as tables. According to the figures, the Brazilian lorry park had the following age structure in the last eight years (1947-54):

0 - 5 years — minimum 50 per cent
6 - 10 years — minimum 35 per cent
over 10 years — maximum 15 per cent

In view of these data, age was projected on the assumption that, in practice, Brazil's lorry park would be so constructed that at least 50 per cent of its units would have a maximum age of five years, and the oldest vehicles a maximum age of 16.

### (c) *Total demand*

Once the total stock of lorries and age composition of the park in the last year (1954) were known, and assumptions had been made as to future age structure and the rate of growth of the present park, total demand was projected up to 1964, as may be seen from table 29. (Data up to 1957 are included for purpose of illustration only).

It appears from this table that Brazilian lorry demand would be about 560 000 units in 1954-64, i.e., an annual average of 56 000 with an annual minimum of 34 600 in 1956.

Table 29

CASE 10. PROJECTION OF TOTAL LORRY DEMAND IN BRAZIL

| | *1955* | *1956* | *1957* |
|---|---|---|---|
| Stocks | 374 000 | 397 000 | 422 000 |
| Total demand[b] | 41 535 | 34 612 | 47 392 |
| Maximum age of lorries in service (years) | | | |
| 1. . . . . | 41 535 | 34 612 | 47 392 |
| 2. . . . . | 39 790 | 41 535 | 34 612 |
| 3. . . . . | 47 671 | 39 790 | 41 535 |
| 4. . . . . | 38 863 | 47 671 | 39 790 |
| 5. . . . . | 64 145 | 38 836 | 47 671 |
| Total, with maximum of five years . . . | 231 979 | 202 444 | 211 000 |
| 6. . . . . | —[d] | 64 145 | 38 836 |
| 7. . . . . | 33 999 | — | 64 145 |
| 8. . . . . | 20 915 | 33 999 | — |
| 9. . . . . | 28 294 | 20 915 | 33 999 |
| 10. . . . . | 18 954 | 28 294 | 20 915 |
| 11. . . . . | 7 830 | 18 954 | 28 294 |
| 12. . . . . | 5 324 | 7 830 | 18 954 |
| 13. . . . . | 2 482 | 5 324 | 5 857 |
| 14. . . . . | 1 211 | 2 482 | . . . |
| 15. . . . . | 11 402 | 1 211 | . . . |
| 16. . . . . | 11 612 | 11 402 | . . . |

*Source*: *Relátorio do Grupo de Trabalho sôbre Indústria automobilística, op. cit.* (On the original study, the table is continued up to 1964).
[a] Projected at a cumulative rate of 6.2 per cent.
[b] Increase of stocks from one year to the next, plus replacements for vehicles taken out of service in the past years.
[c] From 1957 onwards, the premise that this total should not exceed 50 per cent of aggregate stocks has been borne out.
[d] There were no sales in 1950.

Since, however, local production would not begin for at least two years, i.e., domestic goods would not be offered for sale until the end of 1957 or beginning of 1958, the available market would be over 50 000 units *per annum.*

The mechanics of the table calculations may be observed, for example, from the column for 1956. The figure for "stocks" is the sum of the 1955 total, i.e., 374 000, plus 6.2 per cent of the latter (23 000 units in round figures). Stocks in 1956 are thus estimated to be 397 000. Total demand in the same year comprised the 23 000 units added to stocks, plus 11 610 units due for replacement, since they were already 16 years old in 1955, and it was assumed that no vehicles over that age were still in circulation.

Estimates for 1955 followed the same lines as those for 1954, which was the base year chosen for the projection. As to 1957, stocks quoted in the table do not include vehicles of more than 13 years of age, which were eliminated between 1956 and 1957. This is attributable to the fact that from 1957 onwards, the premise that the total number of vehicles up to five years of age should not exceed 50 per cent of total stocks began to be fulfilled. The premise was not confirmed in 1955 or 1956 (possibly because these were the first two years of the programme, when the domestic industry was being installed), but was fully borne out in 1957. For this reason, the total number of vehicles of over five years of age cannot add up to more than 211 000 units, since it should not exceed total stocks of 422 000. Vehicles of over 16 years old were therefore eliminated and it even became necessary to reduce the 7 830 units which were 12 years old in 1956 to only 5 857 vehicles of 13 years old in 1957. Hence, total demand in 1957 would be sufficient to cover the anticipated increment in total stocks (25 000 between 1956 and 1957), and to replace the vehicles which were 13, 14, 15 and 16 years old in 1956 as well as some of those which were 12 years old in the same year (1 973 units, i.e., the remainder after subtracting 5 857 from 7 830).

### *Case 11*

### Study of the market for an iron and steel industry

The following example has been taken from a project —currently under way—which was prepared with a view to satisfying domestic steel demand in a country in process of development. The country's total steel demand was first calculated followed by an estimate of the probable level of demand for the project in question. As the deficit in domestic steel production is covered by imports, the study was designed to obtain specifications of the different steel products imported. In other words, the volume of demand for the project was estimated on the basis of import substitution of steel products purchased abroad. The study also helped to define the type of rolling mill required to meet the specific demand contemplated in the project. The main lines of the study will be explained in the following pages in order to show the criteria on which it was based.

#### 1. *Projection of aggregate steel demand*

Total steel demand in the country was projected in two ways: (*a*) by an extrapolation of the historical trend of the consumption; and (*b*) by a correlation of *per capita* steel consumption with the degree of industrialization reached.

In applying the first method, the series was obtained for apparent consumption (domestic production plus imports) from 1940 to 1955.

A glance at this series shows that it covers two separate periods: one from 1940 to 1945 and the second from 1946 to 1955. During the first, domestic production was small and grew relatively slowly (approximately 40 per cent in the five years), while after 1946, it soared almost quadrupling between 1945 and 1950 and increasing 40 per cent between 1950 and 1954.

Imports also fluctuated sharply, dropping appreciably in 1940-43 owing to the war, and again in 1948-53 as a result of balance-of-payments difficulties which coincided with the increment in domestic production. In 1954, the import series rose abruptly, which project-makers attribute to changes in foreign trade policy which permitted free imports, although at exchange rates which substantially raised their prices in local currency.

Given these abnormalities in the series, the project-makers advanced two alternatives for the study of apparent consumption trends: one based on the entire series from 1940 to 1955 and the other on the partial series from 1944 to 1955, thereby avoiding the war years. If the first series is adopted, the linear growth trend would be some 93 000 tons annually, whereas the second series would place it at about 107 000 tons. If both trends are projected, apparent consumption in 1960 would be 2 118 000 tons according to the first hypothesis (1940-55 trend) and 2 252 000 tons according to the second. In 1965, the respective figures would be 2 582 000 and 2 790 000 tons.

The project-makers point out that complete confidence should not be placed in their projections, because, among other reasons: (*a*) inventory variations were not included; and (*b*) the imports fluctuated considerably and domestic factories were operating without any hopes of early expansion. New estimates were therefore made by a different method, in order to verify the findings and obtain a more reliable projection. For this purpose, it was admitted that *per capita* steel consumption in each country is primarily determined by the country's degree of industrialization, which was defined as the proportion of the national gross product that is formed by industrial production. By using the data from a country series, it was possible to obtain the following regression equation:

$$\log y = a + bx$$

In this, $y$ represents *per capita* steel consumption, $x$ the degree of industrialization and $a$ and $b$ are constants. Three hypotheses—maximum, minimum and intermediate—were assumed for projecting the degree of industrialization.

By 1960, probable demand would be 2 368 000 tons, according to the intermediate hypothesis. This level of demand would be higher than the maximum obtained by extrapolation of the trend, as explained earlier. In 1965, probable demand on the same hypothesis would be 3 462 000 tons, which is considerably more than the results given by the linear trends in simple extrapolation. Deficits in future domestic steel production were estimated on this basis.

#### 2. *Probable deficits in domestic steel production*

The completed projection of total steel demand in Brazil was compared with possible supplies, taking into account present installed capacity, existing enterprises' plans for expansion and new plants under construction that would be finished in the period covered by the projection. On this basis, it was estimated that domestic production would be 1 950 000 tons in 1959, and from a comparison of this figure with projected demand it was possible to deduce the probable production deficit (see table 30).

Table 30 shows that, in order to make up the probable deficit of 600 000 tons in domestic production in 1961, two blast furnaces, each of 1 000 tons daily capacity, would be required. As the study was prepared in 1956, an immediate decision should be taken to install this capacity.

A third blast furnace of 1 000 tons daily capacity should be set up to enter into production in 1962, and a fourth in 1964.

#### 3. *Composition of aggregate steel demand*

The next phase of the study was concerned with determining the steel products for which the largest deficits were registered in domestic production. Table 31 indicates the over-all composition of domestic output of rolled products.

**Table 30**

CASE 11. DEFICIT IN DOMESTIC STEEL PRODUCTION

*(Thousands of tons per annum)*

| | |
|---|---|
| 1960 | 418 |
| 1961 | 600 |
| 1962 | 799 |
| 1963 | 1 017 |
| 1964 | 1 254 |
| 1965 | 1 512 |

**Table 31**

CASE II. COMPOSITION OF DOMESTIC ROLLED STEEL PRODUCTION

*(Thousands of tons)*

| | *1953* | *1954* | *1956* |
|---|---|---|---|
| Shapes and wire | 566.1 | 673.2 | 637.0 |
| Flat products | 275.3 | 297.7 | 392.5 |
| Total | 841.4 | 970.8[a] | 1 029.5 |

[a] Differences due to rounding of figures.

**Table 32**

CASE II. COMPOSITION OF IMPORTS OF ROLLED STEEL PRODUCTS

*(Thousands of tons)*

| *Year* | *Shapes and wire* | *Flat products and tubing* | *Total* |
|---|---|---|---|
| 1951 | 198.4 | 192.4 | 390.8 |
| 1952 | 173.3 | 214.2 | 387.5 |
| 1953 | 81.6 | 144.9 | 226.5 |
| 1954 | 258.7 | 298.0 | 656.7 |
| 1955 | 183.7 | 151.9 | 335.6 |

Table 31 shows that the proportion of flat steel products in total output in 1953, 1954 and 1955 was 33, 31 and 38 per cent respectively. The general average for the three years under preview was 34 per cent.

The composition of imported steel flats is depicted in table 32. The annual share of flats (including tubing) from 1951 to 1955 was apparently 49, 55, 64, 45 and 45 per cent in the respective years, and averaged 51 per cent for the last three years.

It was thus concluded that flats and tubing represented 38 per cent of average apparent consumption of flat steel products for the last three-year period.

This preliminary analysis therefore indicated that there was a potential market for flats and tubing which was worth while studying in greater detail.

### 4. *Types of rolled products in most demand on the market*

In order to obtain fuller information on the rolled products market, a survey was made of 700 consumer firms and 313 of the answers were found to be relevant for the purpose. The survey indicated that, if supplies of rolled

**Table 33**

CASE II. PERCENTAGE COMPOSITION OF TOTAL APPARENT CONSUMPTION OF FLAT PRODUCTS AND PERCENTAGE OF UNSATISFIED DEMAND FOR SUCH PRODUCTS

| *Product* | *1954 Percentage (A)* | *1955 Percentage (B)* | *Deficit 1955[a] Percentage of B (C)* |
|---|---|---|---|
| Hot rolled sheet | 18.6 | 21.1 | 21.0 |
| Cold rolled sheet | 24.0 | 26.2 | 14.0 |
| Tinplate | 45.9 | 42.6 | 17.0 |
| Galvanized sheet | 3.0 | 1.3 | 40.0 |
| Total thin sheet | 91.5 | 91.2 | |
| Thick sheet | 8.5 | 8.8 | 9.0 |
| Total | 100.0 | 100.0 | 17.0 |

[a] Additional consumption that would have been registered if availabilities had been sufficient, expressed as a percentage of apparent consumption.

products had been available, consumption of flats and shapes would have been 17 and 21 per cent more respectively.

The aggregate deficit is broken down into its constituent items in table 33.

The maximum consumption percentage was registered for thin plate; unsatisfied demand was also highest in this item, which in 1955 amounted to 40 per cent of total galvanized plate. The composition of the consumption of the shapes may be observed in table 34.

**Table 34**

CASE II. PERCENTAGE COMPOSITION OF TOTAL APPARENT CONSUMPTION OF SHAPES AND UNSATISFIED DEMAND FOR SUCH PRODUCTS

| | *1954 Percentage (A)* | *1955 Percentage (B)* | *Deficit 1955 Percentage of (B) (C)* |
|---|---|---|---|
| Bars of less than 2 inches | 21.8 | 22.7 | 7.0 |
| Bars of 2 inches or more | 57.1 | 56.2 | 26.0 |
| Girders and angles of up to 2.5 inches | 5.5 | 7.1 | 8.0 |
| Girders of 2.5 to 6 inches, and angles of 2.5 to 4 inches | 7.7 | 7.5 | 27.0 |
| Girders of 6 inches or more and angles of more than 4 inches | 7.9 | 6.5 | 18.0 |
| Total | 100.0 | 100.0 | 21.0 |

**Table 35**

CASE II. TOTAL DEMAND FOR ROLLED PRODUCTS WHICH WOULD HAVE EXISTED IN 1955

*(Thousands of tons)*

| | *Light shapes* | *Medium and heavy shapes* | *Flat products and tubing* | *Total* |
|---|---|---|---|---|
| I. Production | 473.2 | 163.8 | 392.5 | 1 029.5 |
| II. Imports | 144.9 | 38.9 | 151.9 | 335.7 |
| III. Apparent consumption | 618.1 | 202.7 | 544.4 | 1 365.2 |
| IV. Percentage of deficit | — | 21.0 | 17.0 | ... |
| V. Unsatisfied demand[a] | ... | 42.6 | 92.6 | 135.2 |
| VI. Apparent demand[b] | 618.1 | 245.3 | 637.0 | 1 500.4 |

[a] The percentages in line IV were applied to line III in order to obtain line V.
[b] Sum of lines V and III.

If the deficits given in column C of tables 33 and 34 are added to apparent consumption, an estimate may be made of total demand, i.e., what project-makers term "apparent demand", in 1955 (see table 35).

The over-all deficit in the production of steel flats was therefore 244 500 tons (151 900 tons imported plus 92 600 tons unconsumed for want of supplies). The deficit in output of medium and heavy shapes was calculated in the same way and reached 81 500 tons in 1955. In regard to light shapes, it was estimated that 50 000 tons of installed capacity were unused, and the deficit was consequently assumed to be equal to the difference between imports (144 900 tons) and idle capacity, i.e. 101 900 tons.

### 5. *General conclusions of the study*

On the basis of the preceding analysis, the project-makers reached the following conclusions on the market for rolled steel products:

(*a*) In 1955 (the last year of the study), total demand exceeded the supply capacity of domestic production. The difference is estimated as the sum of the deficits in such production which have been broken down as follows:

| | |
|---|---|
| Light shapes . . . . . . | 101 900 |
| Medium and heavy shapes. | 81 500 |
| Flats . . . . . . . . . . | 244 500 |
| Total deficit in domestic supply capacity. . . . . | 427 900 |

(*b*) The most glaring deficit was in the output of flat products.

(*c*) The cut in domestic production of shapes was due to heavier imports.

The examination of difference types of rolling-mills showed that production capacity for broad plate (more than 48 inches), medium shapes and strip was deficient. The same survey revealed that existing iron and steel enterprises intended to maintain their current lines of production, thereby perpetuating the deficits quoted above.

In view of these conclusions, it was decided to project an iron and steel plant to manufacture flats of the type in which current domestic production showed a deficit.

# Chapter III

# PROJECT ENGINEERING

## I. Subjects dealt with in this chapter

Project engineering refers to that part of the study dealing with the technical phase, i.e., the engineers' participation in the stages of study, installation, entry into production and operation of the project.[1] It may be useful to divide this participation into two necessarily conventional parts: engineering services rendered "within" the enterprise (whether for studies or execution) and services contracted "outside" the enterprise, for specialized matters or checking and control. It is obviously necessary to contract specialized engineering services from "outside" in order to solve certain problems, and not to indulge in false economy in this connexion. However good the technicians of the enterprise may be as regards studies or specific operations, they cannot be expected to be experts in all the various specialities, nor to replace experts in new lines without the advice of other specialist engineers. This point is of great practical importance when dealing with projects in which there is no previous local experience. In these cases it is advisable to adopt a broad criterion in the search for the best available advisers, since any apparent saving in this direction may later involve a much greater outlay in other aspects or defects which will burden the enterprise throughout its entire existence. In the study phase, this advice may consist of preliminary information on patents and relevant technical literature, of research into production methods, or other partial aspects of the study, or of the integral technical study of one or more alternatives.

During installation and running-in periods, the advice may cover questions such as the contracting of construction works or installation, assembly of the equipment, supervision of contractors and authorization of payment documents, entry into production, checking of efficiency guarantees in purchase contracts for equipment and other items. Technical studies relating to the preparation and selection of tenders are specially important. The preparation of specifications and analysis of bids normally require highly specialized personnel, and if they are not readily available, it is much better to contract advisers.

The decision to operate with the enterprise's own personnel or with the assistance of advisers also affects the organization of the enterprise for the execution of the project. Obviously, the administrative structure during the execution of the project will vary, depending upon whether administration is direct or through contracts with deferred administration and the employment of temporary advisers.

[1] It has already been explained that the final solutions of technical problems will take into account the relevant economic considerations, and that economic evaluation calculations will be strongly affected by the technical aspects.

## II. Basic aspects of project engineering

The following comments refer more to the technical phase of the study than to execution and deal briefly with the fundamental engineering aspects to be considered. The only object of the points mentioned is to indicate in general terms the problems arising in the technical phase of the project, and to offer some hints as regards their presentation. Their relative importance will vary with the project, but they will fall under the following headings: (1) preliminary research and testing; (2) selection of the production process; (3) specification of operating and assembly equipment; (4) buildings and site layout; (5) plant lay-out; (6) supplementary engineering projects; (7) efficiency; (8) flexibility of productive capacity; and (9) work schedules.

### 1. *Preliminary research and testing*

All engineering projects require, to a greater or lesser degree, a certain amount of preliminary tests and research which determine many of the decisions adopted in the course of the study. These tests cover widely varied matters: simple strength tests of the site for the construction of buildings; laboratory or pilot plant tests of the possibilities of using certain raw materials or processes, and the conditions under which such uses will be possible; experiments with new crops; metallurgical research into the treatment of ores, etc.

The project itself need only contain a clear summary of the information regarding these tests and research; the complete text of the respective reports may be attached as appendices or annexes.

### 2. *Selection and description of the production process*

In many cases there are no problems regarding the production process or system, but in others complications and alternatives arise which should be explained together with the solutions offered, in relation to the preliminary research.

The process can be more easily described by the use of simple drawings or flow diagrams, which help to clarify and improved the presentation.

### 3. *Selection and specification of equipment*

There are two stages in the selection of equipment: (*a*) choice of the type, in order to draw up the specifications for the bids; and (*b*) selection between the various equipments of the type chosen in order to decide between the bids.

Selection of the type of equipment is of special importance when studying the project; it will be greatly influenced by the nature of the process, the scale of production and the degree of mechanization, all of which are closely inter-connected. It may often happen, for instance, that a certain degree of mechanization is only applicable above a certain production level, and similarly certain processes lend themselves better to mechanization than others. (For example, some types of farming or working methods for mines will allow only a limited amount of mechanization, while others offer much wider possibilitities.) The type of production is thus related to the degree of mechanization.

In the large industrial centres there is a trend towards the replacement of labour by equipment (automation), which implies factors such as mass production, optimum organization, availability and efficiency of supplementary services to ensure the systematic and opportune circulation of input materials to the manufacturing centre; a disciplined and efficient labour force and good distribution systems.[2]

The size of the market and the availability of investment capital resources as well as problems related to the general technical level are the factors which limit the possibilities of automation, with its resultant higher productivity of labour, in the under-developed countries. In any process or scale of production there is a certain amount of leeway as regards the degree of mechanization to be adopted. The possibility often depends upon transport problems, either within or outside the actual production centre (loading and unloading of material), transport to the warehouses, and movement of raw materials from the stores to the machines, etc.

The choice between equipments which meet the required specifications, after the selective analysis of types, arises only after the decision to execute the project has been made. As already stated, the analysis of bids is seldom easy: it is not only a question of choosing the lowest bid in direct terms, but of selecting the most economic in the final balance. The problem is often complicated by financial considerations or the nationality of the source of supply. Credit facilities, rates of interest, type of foreign currency required—convertible or not—and other considerations may play an important part in the decision.

Finally, it must be remembered that projects normally require two types of equipment, whose relative importance will vary according to the nature of the project: one necessary for installation, and the other for operation. In the case of road projects, for instance, the most important equipment is that required for construction. This type of equipment is also very important in hydroelectric or irrigation projects, and in general, all those which involve large-scale movements of earth. For industrial manufacturing, on the other hand, the heaviest item is the operating equipment. The two types must be specified with the amount of detail corresponding to their relative importance.

[2] There is one type of technical alternative which bears no reference to different processes, more complicated machinery or greater mechanization. This is what are called "controlled conditions shops" where, by means of uniform lighting, control of temperature and humidity, better dust and germ elimination from the air, better noise suppression and similar measures, increased production and improved quality can be obtained. This results in reduced costs and greater productivity per man and per unit of basic equipment. Controlled conditions shops involve a higher investment than the normal shop, and therefore represent an alternative with higher capital intensity; only the economic analysis will show if the reduced operating costs will offset the higher initial cost.

### 4. *Industrial buildings and site layout*

The engineering project must include estimates of the size and characteristics of the buildings required for production and site layout. For agricultural projects this will include stables, barns and similar buildings; for mines they will be the surface buildings for housing machinery, workshops, etc. The problem acquires special interest in the case of manufacturing industry, because the distribution of the industrial buildings has an important bearing on the handling and flow of raw materials, materials in process of manufacture, and finished products. Reception areas, stores, central workshops and other installations must be functionally situated as regards the main factory building and transport services. It is very important to foresee possible expansions from the start, so that the initial harmony will be maintained. Although these are engineering problems outside the scope of this *Manual*, emphasis must be placed on the necessity for viewing the problem from the widest possible angle, foreseeing the amount of leeway which may be allowed in the general arrangement of buildings and free space, so that, in the case of expansion or the introduction of new techniques, it will be possible to proceed without undue difficulty.

The first direct application of this point of view arises when purchasing the site, and deciding where to carry out the project.

In countries in course of rapid development, industries are often restricted by the original site, the result being reduced efficiency in one way or another. Even when no expansion is foreseen for the immediate future, it is always as well to take the possibility into account when purchasing the site.

The study of the flow of raw materials, fuels and other items is of special importance. Emphasis should be laid on rail and road connexions to and from the industrial site and the internal layout of such connexions between the industrial buildings. Solutions should be sought which allow traffic to flow in one direction, so far as possible, with a minimum of crossroads and with an eye to possible future expansion. A traffic diagram will be helpful in explaining, justifying and presenting the solution arrived at.

### 5. *Plant layout*

The layout of equipment throughout the factory or plant involves the consideration of similar points to those raised in connexion with efficiency and possible expansion of production. Space has to be allowed for expansion and for the later adoption of new techniques, etc. This matter will receive greater or lesser attention, according to the nature of the project. For example, in agricultural projects it will have but little importance, whereas in manufacturing projects it will be a major consideration.

The efficiency of a manufacturing operation depends to a great extent on the layout of the equipment, since this can lead to economy in movement, time and materials, and in general to the dynamic ease of the process. The same quantity and quality of production factors may give better or worse results depending on the organization of combinations and flow resulting from the layout of the production equipment. Those responsible for operating the industry will find their task all the easier if these problems are anticipated at the study stage.

### 6. *Supplementary engineering projects*

Projects must often cover additional installations to supply the services needed for actual production or for the persons who will work on the project. Clearest examples of this are supplementary works for drinking or industrial water, the removal of residual water, electric power connexions, gas-pipes or surface transport connexions,[3] the construction of camps or housing estates, administrative offices, welfare buildings for the population, etc.

Consideration of these supplementary works arising from the project's technical requirements—industrial water, electric power and similar items—will be more exacting than in the case of those needed to serve the population. The quality and quantity of the buildings for housing, camps and welfare services, will be more elastic, since in this case the criterion will be both economic and social, and will vary with circumstances. A solution has to be sought which is reasonable in cost, but which will at the same time provide the minimum comfort required by the workers and employees. This minimum will depend on local conditions and the good judgement of the sponsors of the project, and the decision will always involve a certain degree of subjectivity.

On many occasions, the technical requirements as to quantity and quality of certain fundamental goods or services, such as water and electricity, will have a very important effect on the site and other aspects of the project.[4] They may therefore require prior study and research of a decisive nature as regards the specification of equipment and methods, as already seen.

This association of various supplementary projects with the principal or central project may be indispensable in the case of agricultural, mining or industrial projects, which because of their nature must be situated close to natural resources and far from urban centres.

### 7. *Efficiency*

Once the manufacturing method, the size of the plant and the arrangement of equipment and buildings has been decided, it will be possible to calculate the volume of each type of input required by the project, both for installation and operation. Once the volume has been determined in physical terms, operating and input costs can be estimated. Moreover, this volume serves as a useful element of comparison when appraising the estimated administrative and operating efficiency of the enterprise.[5]

The volume of input according to the physical processes employed, the quality of the available raw materials and the experience of other plants, can be estimated with the help of the preliminary technical research. In addition to the purely technical factors, these estimates should also take into account the industry's general administrative and technical organization and the quality of the labour available. This may lead to specific recommendations regarding the organization and administrative structure of the enterprise, training, contracting of special advisers, etc.

It is a common practice for enterprises to have laboratories for the technical checking of raw materials, the actual production process, semi-processed articles at various stages and final products. The achievement of given outputs and compliance with specifications will depend to a large extent on this technical checking. Attention should thus be paid in the project to these laboratories and their method of operation.

### 8. *Flexibility of productive capacity*

This point has already been discussed in connexion with the plant layout. The need for flexibility in productive capacity is at times a result of the nature of demand; at others, it may depend on temporary limitations in the availability of raw materials, or a tight financial situation, which means that production has to be started on a limited scale in the first stage. Naturally there are limitations in the approach to these problems, but if the conditions mentioned earlier should exist, in the technical study of the project solutions should be sought which will tend to facilitate harmonious growth and permit flexibility of operation with the minimum of drawbacks, interference and cost.

Adaptation to seasonal demands necessitates flexibility from the point of view of achieving efficient production at different rates of output.

### 9. *Work schedules*

The work schedule establishes the order of installation and entry into operation of the enterprise. Its purpose may be summed up as follows: (*a*) to foresee a series of problems which will arise at the installation stage, and anticipate possible solutions; (*b*) to establish a sequence of investments, which will provide the basis for studying the financing of the project; (*c*) to establish a preliminary plan of operation to cover the running-in period.

In order to examine the problem in more specific terms, some ideas are given here regarding work schedules relating chiefly to manufacturing projects, but they will be valid in the main for any type of project, as may be seen from the examples or cases relating to this chapter.

The work schedule in a manufacturing project must ensure that the entry into operation is synchronized with the arrival or availability of the raw materials. This latter factor may not be important if the raw materials are to be produced in any case, or if they are not perishable. For instance, a project for an iron and steel industry whose basic raw materials—coal and iron ore—are already being produced for export will not as a rule present any synchronization problem; when the industrial installation is completed, the raw material will be available. But if some of the materials must be imported, the work schedule must include the placing of the orders abroad, so that their arrival will be co-ordinated with the entry into operation of the enterprise. This will undoubtedly always be a problem for the industry, but from the point of view of the installation work schedule, all contingencies must be foreseen up to the stage of normal operation of the industry. The transition from the construction to the operational stage should be as smooth as possible. This point becomes

[3] For example, high tension lines in the first case, and railway sidings or branch roads in the second.

[4] See chapter IV of this part.

[5] Even when the project specifies a certain output in relation to raw materials, fuel, labour and input in general, in practice this may vary according to the administrative and technical competence of the management of the enterprise.

especially important when the raw materials are perishable or depend upon a harvest; the work schedule will then be of decisive importance for synchronizing the completion of installation with the beginning of the harvest, since the permissible leeway in this case might only be a matter of weeks. It is advisable to leave ample safety margins, so that the factory always awaits the raw material, and not *vice versa*. Nevertheless, it is not always possible to do this for reasons beyond the control of the project-makers. There is always a danger in contracting a harvest, only to find that the industry is not ready to process it. At the same time, to keep an investment idle for a considerable period of time increases costs, because interest accumulates during the installation period up to the time of entry into operation; this imposes a limitation on the advance completion of the installation, which again emphasizes the importance of the work schedule.

The converse of this problem arises when the project has operating enterprises dependent upon its termination, as in the case of mining projects which are to provide raw materials or fuel to industries which are being installed in anticipation of the project's production. The same may apply to roads or power stations for parallel projects. Well-synchronized dates may be most important, and well-studied progress charts may be decisive in meeting them.

Since the decision to execute a project may be taken before the completion of the engineering studies concerning installation, it often happens that final details are not obtained until the actual installation period. For instance, it may be that full details are available on the industrial buildings and machinery, but not on those of the housing estate for the personnel, or the supply of industrial water. The uncompleted engineering studies will coincide with the installation phase, and should therefore be included in the working plan. It is thus often useful to divide the programme into two parts, so that both phases may evaluated.

Finally, it is important to remember in the programme the time required for testing the installations and running them in. The industry does not commence to operate immediately the installation is completed; adjustments are necessary, and checks and corrections must be made before beginning normal operation. This involves both time and money, and for this reason it ought to be included in the project. The equipment and machinery normally have a guaranteed output, which must also be confirmed during the test period, allowance being made for further time in case adjustments are necessary to bring the output up to the guaranteed level. The whole running-in period prior to normal operation must therefore be included in the project.

### *Case 12*

#### THE SERVICES OF CONSULTANTS IN THE STUDY AND EXECUTION OF A MANUFACTURING PROJECT

Reference has been made in the text to the various levels of preparation between the origination of an idea and the final project. In order to illustrate some of these levels, an outline is given below of a manufacturing project based on the services which consultants can offer. Each stage of the study can obviously be regarded as a separate item as regards contracts and fees. The general plan must be adapted to each specific case; it is divided into the following four phases:

#### *Phase I*

This consists of preliminary studies, with the principal object of deciding whether the project is feasible or not. It should cover the following points:

(*a*) Preliminary technical research; examination of bibliography and of possible patents; conducting of laboratory tests.

(*b*) Preliminary market analysis.

(*c*) Studies of prevalent sizes of the industry and guidance regarding sites.

(*d*) Selection of the process, and analysis of technico-economic alternatives; preliminary design of special equipment and apparatus; general specifications of the machinery.

(*e*) Plant layout; flow sheet and general arrangement of the buildings on the site.

(*f*) Diagrams and sketchs.

#### *Phase II*

This phase will prepare the project for evaluation; the essential points will be:[1]

(*a*) Closer study of the process to be used, or of production methods in general.

(*b*) Study and final decision on size and site.

(*c*) Detailed costs study.

(*d*) Possible negotiations regarding patents.

#### *Phase III*

The entry into phase III implies that it has been decided to execute the project, and that advanced execution studies are required. Studies may be contracted to cover matters such as the following:

(*a*) Preliminary projects for buildings; preliminary lay-out of plant; construction methods and materials.

(*b*) Site layout. Situation of the most important buildings; interior roads and railway sidings; parking lots, raw material storage areas; stores and warehouses in general. Traffic diagram (entrances and exits).

(*c*) Specifications of machinery and equipment, both standard types and those which require special designs (as in certain chemical industries).

(*d*) Preliminary studies of the supply of basic services (water, steam, electricity, drainage and sewerage).

(*e*) Once the preceding points are approved, final plans and building specifications could be contracted. This study would include the entire system of piping, tubing and water distribution, supply of electricity and water, lighting installations, etc.

(*f*) Probable work programme and investment schedule or time-table.

#### *Phase IV*

This phase covers the organization of the enterprise which will execute the project and includes items such as:

(*a*) Technical assistance in inviting tenders, and the best methods of drawing up contracts.

(*b*) Preparation of the final work programme and investment schedule.

(*c*) Studies of the site (topographical plans, photographs, resistance tests, etc.).

(*d*) Direction and co-ordination of sub-contractors.

(*e*) Organization of construction, of its accountancy and of the control of payments to contractors.

(*f*) Inspection of the construction and final technical inspection.

### *Case 13*

#### INVITING TENDERS FOR THE STUDY OF, SUPPLY OF EQUIPMENT TO, AND PUTTING INTO OPERATION OF A COPPER SMELTER

This case gives a better idea of what the inviting of tenders involves and of some of the ideas expressed in the text regarding the various stages of a project, especially those between the approval of the preliminary project and the entry into operation.[2] It also shows some of the steps that must be taken in advance to ensure flexibility in the expansion of production capacity and to simplify future construction problems.

In order to obtain a better understanding of the background of the tender used as an example, it is as well to know something of the development of the project. The project is a smelter for copper, gold and silver ores, which must receive these ores from a number of small and medium mines situated in various parts of the country. These circumstances complicate the problem of selecting a site and, in section III, it is therefore presented in general terms only—"on or near the coast". The inviting of tenders and the decision to install a new smelter in the country were undertaken although the problem of the exact

[1] Social evaluation requires additional data as explained in Part Two of the *Manual*. Only those requested from a firm of consulting engineers are given here.

[2] This is the same project as that used for the determination of size in case 26.

site was unsettled, since it was sufficient to have a general idea. The decision was based on preliminary studies carried out by various project-makers, who were in agreement concerning the advantage and advisability of the project in general and the approximate site, but who disagreed about the most suitable place. In addition to permitting an evaluation, which justified the decision to make the investment, the preliminary studies helped to establish the technical bases for the tenders in such matters as size and general site, characteristics of the ores to be processed, general layout of the installation, and other data.

The different stages of the project show up clearly here: first the idea arose of processing, within the country, ores which are at present exported raw; afterwards preliminary studies were begun to entertain the possibilities of executing this plan. The preliminary studies provided sufficient details to allow evaluation and a decision to be made. The evaluation consisted in comparing the economic results of the direct export of the ores and concentrates with those which would be obtained from their processing in the country. From the data in the studies, the comparison favoured the idea of installing a smelter, both from the point of view of foreign exchange income and as regards the prices which could be paid to the producers of the ore. The evaluation also took into account the fact that the existence of a new smelter would stimulate production in a number of local mines, for which transport costs had previously been prohibitive. Finally, the decision was strongly influenced by the fact that the enterprise possessed the financial resources for the execution of the project. Once the decision was taken in principle, the subsequent questions were formulated in the manner explained below.

The bases and specifications of the tender are outlined in five sections. The first is reproduced almost in its entirety, since it contains the general bases. The second mainly concerns the local characteristics and technical details which must be considered in the preliminary project—meteorological conditions in the area, availability of outside electric power, transport facilities, technical construction standards and stability of buildings and structures, provision for expansion, electrical conduits, ducts and cables, electrical circuits and internal railway lines—and is not reproduced because of its nature. The third refers to the technical specifications for the smelter and the sulphuric acid plant which will employ the gases produced during the roasting of the sulphides; it is reproduced in part, where the items best serve as illustrations for this *Manual*. The two remaining sections contain similar technical specifications, but refer to an electrolytic copper refinery which will be installed together with the smelter, works which will be carried out by the enterprise itself, and relations with the contractors. Parts of both have been omitted here. It should be noted that the bids were requested not only for equipment and machinery, but also for the "study of the preliminary project", and for the final planning. It is thus admitted that the preliminary studies were limited to two basic objectives: to decide on the investment and to establish the bases for the tender. The enterprise requesting the tenders is in the public sector. Although it is already successfully operating a similar smelter, it was considered advisable to invite bids for a definite study of the new project and to examine the question of installations, in order to take advantage of technical progress in highly specialized processes. This criterion again confirms that savings on costs of technical services are ill-advised.

In the text of the tender reproduced below, the parts considered to be most interesting from the point of view of this *Manual* are underlined. Apart from the use of services, the following points should be noted: (*a*) the consideration given to the work schedule for installation (section I, point 8); (*b*) legislation concerning foreign personnel (section I, 15); (*c*) specification of a single foreign currency in the quotations, in order to avoid ambiguity and confusion in comparisons (section I, 19); (*d*) forecast of the facilities required to handle heavy or bulky items (section I, 21); (*e*) provisions to ensure technical operational efficiency (section I, points 35-39 and 44); (*f*) flexibility in size and expansion of installed capacity (section III, 10).

### *Section I*

#### A. *General conditions*

Tenders are requested for the following:

1. Supply of the basic equipment, in accordance with the preliminary project to be prepared by the bidder of the principal elements for the processes of smelting, refining, and manufacture of sulphuric acid, from the reception of the raw material to the delivery of the finished product, as laid down in the attached Technical Specifications. The merits of the preliminary project presented by the bidder will be taken specially into account in the award of the contract.

2. In the case of the favoured bidder, the provision of services:

(i) *To transform the preliminary projects into the final plan of the installations;* and

(ii) *To supervise construction,* entry into operation, operation, and training of national personnel.

3. Bidders must quote for complete groups, that is to say, for the smelter, with its sulphuric acid plant, and the electrolytic refinery. Bids for only one of these groups, or for only a part of the basic equipment of any of these works, will not be considered.

4. Notwithstanding the foregoing, bidders should indicate separate prices for each group, according to the details given below; aggregate bids for the whole of the two groups which do not enable the enterprise to distinguish clearly between the separate groups will not be considered.

5. Bidders must include in their tenders all main and auxiliary items and accessories which are normally used in the process, and which are necessary for the proper functioning and safety of the installations, even though these may not be expressly mentioned in the specifications. For this purpose they must give precise details of the material included in the quotations, and also the origin of the material (name of the manufacturer). The enterprise reserves the right to request a change of manufacturer if it so desires.

6. *The bidders must indicate in particular which items are patented, and what royalties or patent rights, if applicable, the enterprise would be called upon to pay.* If no mention is made of this subject, the enterprise will assume that the bidder assumes responsibility for all obligations related to patents or royalties of any type to which the equipment, or its subsequent use for an indefinite period by the enterprise, may be subject.

7. Without exception, bidders must give quotations for machinery, accessories and elements of the highest quality, which, in all cases, must comply with official specifications and standards in force in the country of origin. A list of these specifications should accompany the bid.

In their prices they must include all the best practicable safety and protection devices both for the protection of the machinery and to avoid accidents at work. They should include in the specifications a complete description of the main systems, such as alarms, interconnexions, etc.

8. *As a separate item* in the tender, bidders *must give quotations for the rendering of services for transforming the preliminary project into the final plan,* consisting of construction plans, details of installation, and construction specifications for the rapid completion of the work in Chile. Preference should be given to the following:

(i) Preparation, immediately after the notification of acceptance of the tender and handing over of the plans of the site, of dimensional drawings which must be used in Chile for projection of the buildings and supplementary works for the process, of a list of the weights and concentrated loads which must be taken into consideration for the buildings, and the individual and sets of drawings which will be required for these purposes;

(ii) Dimensional plans of foundations, showing distance between the various elements, ducts, passages or inspection covers which must be installed, and any other details which are necessary;

(iii) General plan of electrical distribution layout for all process, auxiliary and accessory equipment, and for lighting of all sections; 3-line diagram of supply and control circuits;

(iv) Diagrams or plans, as required, of the water supply and of the drains of the various sections. The water supply to these sections will be from one or more principal distribution tanks, the location of which should be suggested by the bidder. This must also show the consumption of each section. The water supply works up to the principal tank or tanks will be projected and executed in Chile by the enterprise.

*The contractor must deliver the preceding work to the enterprise in the order which best suits the work schedule in Chile, so that the preparatory work in this country may proceed in the correct order, unnecessary expenses are avoided, and finally that the installations may proceed in accordance with a satisfactory schedule.*

9. *Bidders may quote an aggregate price for the services to be rendered in each group, or as fees expressed as a percentage of the estimated value of the work (basic equipment, accessories and connexions), indicating the approximate value for comparison purposes.*

10 to 13. Method of presentation of the plans.

14. The second item of services rendered to be quoted by the bidders *covers the provision of technicians and specialists for supervising the installation,* to the extent which the bidder considers necessary in order that he may accept the responsibilities indicated below, the running-in period and initial operation, as follows:

(i) Bidders should indicate in their offers the number of persons considered necessary, stating their respective specialities;

(ii) Bidders should quote their fees in the form of a daily wage or monthly salary, to be paid from the date of their departure from the factory to the date of their return after a direct journey. The enterprise should pay these amounts directly to the contractor, who should deal directly with the contracted personnel in all matters of payment. The enterprise should also reimburse the contractor for the travel of these persons to and from the country, and should pay all direct travelling expenses, such as passports, luggage or incidentals, but excluding personal or entertainment expenses.

The enterprise should have no direct responsibility for these persons, and they should deal directly on all matters of remuneration, travelling expenses, social laws, etc., with the contractor, who should be their sole employer.

The enterprise should provide these persons with free lodging and maintenance at the site of the work.

15. *This personnel should not be subject to Chilean social laws,* but the enterprise should protect them against occupational hazards under the general policy covering all higher level national personnel.

16. The contractor should be entirely responsible for the competence of these persons to execute their appointed tasks. If there is dissatisfaction in this respect, and the enterprise justifiably requests any replacement, the cost should be borne exclusively by the contractor.

B. *Compensation to bidders*

17. The enterprise should decide upon the bids within approximately 120 days from the closing date. If it is decided not to award the contract to any of the bidders, each of them should be given 30 000 dollars, as compensation, under the following conditions:

(i) The bidders must have presented complete preliminary projects including the plans, specifications and descriptions indicated in these bases;

(ii) The bidders must have signed a legal document which permits the enterprise to use the preliminary project in any basic plan for the selection of equipment or for general installation layout;

(iii) If the bidder does not wish to accept the above conditions, the enterprise should undertake to return the tender with all its enclosures, without retaining copy. In this case, the bidder should not receive compensation.

18. If a tender is accepted, the favoured bidder should receive no compensation, since it is understood that the remuneration for the preliminary project is included in the profits which have been calculated for the equipment and included in the quoted prices.

The unsuccessful bidders, in this case, should receive compensation for their preliminary projects in the amount of 10 000 dollars each, provided that their preliminary projects meet the conditions of clause 17, paragraph (i), and after signature of the document specified in paragraph (ii). Failing such acceptance, action should be taken in accordance with paragraph (iii) of the same clause.

C. *Prices and method of payment*

19. *Prices for the supply of equipment for the process must be quoted in the currency of the country of origin and in its equivalent in United States dollars, for delivery f.o.b. port of shipment, including the cost of packing for ex-*

*port and of the necessary dismounting required for shipment.* The prices should be quoted for each complete unit (for instance, in the case of the reverberatory furnaces, for the whole of the refractory bricks and for the structures which form an integral part of the unit, but not for the bricks as such; the fuel injection equipment; cooling, etc.). In the same way quotations should be given for the complete recuperation boiler, including all auxiliary and accessory equipment per unit of turbine and generator, etc.

The quotation for services rendered should be prepared in the same manner.

20. The connexion elements between units should be quoted according to the general dimensions given in the preliminary project. These figures should be subject to adjustment as regards quantities of materials at the unit prices indicated in the tender in order to conform to any changes incorporated in the final project.

21. As far as possible, bidders must enclose with their offers a list showing *the approximate shipping weight and volume* of the various units, so that the enterprise can estimate the approximate transport costs, and *any special facilities which may be required for the handling of heavy pieces on the site.*

22. The prices quoted in the tender for the supply of the equipment should hold good until 120 days after the closing date. Tenders which do not comply with this condition should not be considered.

23. Bidders must indicate the approximate shipping dates of the principal units of the basic equipment, and, according to this time-table, they should specify in their tenders the price adjustments which they would demand if the cost of labour and materials changed after the expiry of the time-limit mentioned in the preceding paragraph.

24. In this connexion, the tenders should specify the formula for changes in prices and the official indices in the country of origin of the equipment which will be used to calculate any adjustments, so that the enterprise may verify the indices.

25. The enterprise should pay for the supply of the equipment and for services rendered as follows:

(i) An instalment not greater than 20 per cent of the total f.o.b. value of the equipment to be supplied and of the value of the final project paid by means of a documentary letter of credit, with partial payments to cover the delivery to the enterprise of the different elements of the project, specifications, construction drawings, materials lists, etc., referred to in paragraph 8, in a manner which will enable the enterprise to begin work in Chile at the earliest possible date.

The contractor must take out a fidelity bond, or similar guarantee, with approved underwriters in favour of the enterprise for this 20 per cent of the value;

(ii) Thirty per cent of the value of materials shipped, payable as complete units are shipped, so that when the final shipment is made, the contractor will have received 50 per cent of the value of the contract;

(iii) The remaining 50 per cent in equal quarterly payments over a period of three years, starting from the date of the final shipment of the contracted material;

(iv) Payment for services rendered, referred to in paragraphs 2 (*b*) and 14, should be paid for in cash as the services are rendered.

26. The conditions laid down in the preceding paragraph are the maximum which the enterprise can accept for the payment of the equipment and services rendered, and the bidder may offer better conditions for a longer deferment of payment. These conditions should be taken into account in the award of the contract.

D. *Presentation of quotations*

27 to 30. Details on the presentation of quotations.

31. As regards the supply of equipment, the contractor should guarantee the quality of all the elements, both as regards the materials used and their compliance with the corresponding specifications and as regards their finish.

32. This assumes that the contractor will inspect the material in the factory during manufacture and testing in the manufacturers' shops, and that he will insure against all risks from factory to the site, including 90 days in the customs in Chile.

33. It is also understood that, on the arrival of the material in Chile, the enterprise will unload, inspect and store it in a suitable manner and make any tests or checks which may be required, e.g., for breakages, dampness, and cleanliness. The enterprise should request any replacements which may be considered necessary and prepare the material for any inspection which the contractor's technical personnel may deem necessary before installation.

34. As regards the construction work to be undertaken by the enterprise, the latter, or its representatives, should use the best precision instruments to determine and check the measurements and dimensions established in the contractor's plans. The contractor's technical personnel should check them again, if they consider this to be necessary, before starting the installation, and should compel the enterprise to correct immediately any discrepancy or error which they may find.

35. In their tenders, the bidders *must indicate the guaranteed efficiency of each of the main units of the process at different charges and under the conditions and normal tolerances which are specified in such guarantees.* Compliance with these guarantees should be checked in the factory whenever this is possible and the contractor should provide the enterprise in due course with the corresponding certificates.

36. *The initial operation of the process should be under the direction and responsibility of the contractor, who should prove to the satisfaction of the enterprise that the level of efficiency and production capacity are in accordance with his tender.*

37. Individual efficiency tests should be made in conformity with the standards of the country of origin.

38. *Bidders should indicate in their tenders the penalties which they will accept for non-compliance with the individual and combined levels of efficiency which have been guaranteed in their tenders.*

39. Notwithstanding the other provisions of this chapter, particularly those in article 32, the enterprise reserves the right to inspect any element or part of the basic equip-

ment, in the factory during construction, either using its own personnel or through an approved inspection agency. *This inspection does not release the contractor from any of the obligations laid down in these bases or in the contracts.* Any tests in the factories or laboratories should be made without charge to the enterprise, which should only pay for those tests which may be ordered by its own personnel or the inspection agency and which are made in laboratories other than those of the factory or the contractor. In these cases it is understood that the factory or the contractor must supply free of charge any test pieces which may be required.

E. *Reception of the equipment*

40. The reception of the equipment will be in two stages: provisional and final.

41. Provisional reception takes place once the equipment is completely installed and the installation placed in operation by the contractor. The contractor's technical personnel, in the presence of and with the assistance of the enterprise, should carry out the tests previously agreed on in order to check the efficiency and proper functioning of the equipment.

42. A record of this provisional reception should be made and signed by representatives of the contractor and the enterprise and any observations should be noted.

43. The contractor must exchange, at his own expense and risk, any machinery, materials or accessory which, during the running-in period, provisional reception tests, or the period of operation under the responsibility of the contractor, are found to be defective or not to comply with the specifications or standards laid down regarding their supply.

44. Final reception takes place *six months after the provisional reception.* During this period the operation should be supervised by the contractor's technical personnel, who should be responsible for the following:

(*a*) Projection, at no charge to the enterprise, of any changes or modifications shown by experience to be necessary;

(*b*) Replacement of units or parts whose performance is inadequate or abnormal for their basic purpose, or which prove to have insufficient capacity for the guaranteed output.

F. *General provisions*

45. Once the decision has been announced by the enterprise, the favoured bidder has to appoint a representative in Chile with whom the enterprise may deal in all later business with the contracting firm, on the understanding that this representative will have responsible and competent personnel at his disposal.

46. Once acceptance of a tender is notified in writing, the favoured bidder must enter into a contract in Chile through a legally appointed representative.

In any case, the enterprise reserves the right to include in the contract or contracts all stipulations which it considers necessary to safeguard its interests.

*Section III. Technical specifications of the smelter*

A. *Fundamental concepts and plans*

1. In order to smelt copper ores and concentrates which are at present produced in the central zones of the country, it has been decided to install a blister copper smelter not too far from the centre of production.

2. *This smelter will be situated on the coast, in a protected bay, or a short distance from the coast, linked to the port of access by a short rail or road route.*

3. As an annex to the smelter, an electrolytic copper refinery will be installed. This plant will refine not only the blister copper from the new smelter but also that produced by the Paipote smelter.[3] Its capacity will therefore be at least double the present output of Paipote, which is estimated at 15 000 tons of blister per year.

4. The smelter must be sufficiently flexible to work at variable capacity without unduly increasing melting costs.

5. Advantage will be taken of the greatest possible proportion of the heat of the waste gases of the reverberatory furnace, since all excess electric power produced will be used in the electrolytic copper refinery or fed into the local distribution network. *Nevertheless, since the refinery may not be completed when the smelter begins its first operation cycle and since it may prove impossible to make the connexion to the external network, a steam condensation plant should be considered with sufficient capacity to avoid the need to install artificial loads for the electricity produced.*

6. Part of the concentrates arriving at the smelter will be roasted in order to halve their sulphur content. Sulphur dioxide will thus be produced for the manufacture of sulphuric acid in a lead chamber plant or by some other method. This acid will be employed in part to replace losses in the refinery and in part to produce copper sulphate.

7. If the sulphur required to form the copper matte does not enable a sufficient quantity of concentrates to be treated to produce the require quantity of sulphuric acid, it is advisable to provide for this latter purpose, for the possibility of using the more concentrated portion of the waste gases from the converters or the waste gases from the reverberatory furnaces.

8. The plant where the concentrates, ores and fluxes are received must be able to check the weights and sampling accurately and must be so arranged that the materials, after being crushed and sampled, may either be routed normally to the sedimentation bins or to reserve stocks, where separate storage will be available for up to 30 000 tons of ore, concentrates and fluxes. From the reserve stock these materials will be transported again to the primary reception bins, where they will be re-weighed and re-sampled and finally deposited in the sedimentation bins. This part of the plant will not be included in the preliminary project, since its characteristics will depend upon the space available, the conditions and contours of the site.

9. To sum up the preliminary project of the smelter must include the following sections and out-buildings:

[3] Paipote is the other smelter in Chile.

(i) *Reception,* which will include railway and lorry weigh-bridges, primary reception bins for ore and fluxes, and the reception bins for concentrates.

(ii) *Crushing and sampling,* which will include means of transport from the primary bins to the crushers and samplers or to the concentrate roasters; the various crushers with their respective grills or vibrating screens; automatic samplers, means of transport, both internal and from the crusher and samplers to the bedding bins.

(iii) *Bedding system,* which will include the means of transport for the distribution and loading of the materials in the auxiliary and bedding bins; to collect these materials from the beds and carry them to the reverberatory furnaces and to collect the materials from the auxiliary bins and transport them to the reverberatory furnaces or converters.

(iv) *Reverberatory furnaces,* which will include the feed hoppers for the furnaces; means of transport between these hoppers and the side chargers of the furnaces, whether chain transporter or tubs; weighing machines or scales; the furnaces with their oil burners; the recuperation boilers, two per furnace, ash deposits, dust hoppers, smoke ducts and principal smoke stack.

(v) *Converter bay,* which will include the converters with their tipping and loading equipment; anode furnace with poling platform; melting furnace for blister copper from Paipote, which may be installed in the reverberatory furnace bay; circular ingot mould rack for the semi-refined copper from the anode furnace; straight ingot mould rack with automatic lifting and aligning of the bars of blister copper; travelling cranes for transport, loading and unloading materials; balloon flues of the converters.

(vi) *Roasting,* which includes means of transport between the primary reception bins for concentrates and the roaster or roasters, with their respective burners, compressors and pyrometers; the sedimentation equipment for heavy dust; Cottrell precipitator for fine dust; gas detector and automatic analyser of sulphur dioxide.

(vii) *Dust collector,* which will include; (*a*) a pneumatic installation for transporting the fine ash from the boilers and the dust from the smoke chambers and flues, both of the reverberatory furnaces and the converters, and from the sedimentation equipment and the Cottrell precipitators, to an agglomeration plant; (*b*) sintering plant, and the means of transport to return the ash and powder sinters to the loading belt of the reverberatory furnace feeder hoppers.

(viii) *Motive power,* which includes, apart from the recuperation boilers already included in section (iv), the steam condensation plant and its pumps, accessories and water cooling arrangements; turbo-generators with switchboards, and measurement, protection and control instruments; turbo-compressors; water treatment plant, and all transformers, converters, motors, air lines, cables and auxiliary materials required for the distribution and use of the electric power required in the smelter.

(ix) *Measuring and control instruments,* which includes all measuring instruments, indicators and recording instruments needed for regulating the operation of the reverberatory furnaces, recuperation boilers, turbo-generators, and in general, all installations, machines or accessories where operation must be observed, either intermittently or continuously.

(x) *Laboratory.* There will be no need to quote for a chemical laboratory, but its location and general dimensions must be included in the preliminary project.

(xi) *Sulphuric acid plant,* which comprises accumulation and mixing tanks for the waste gases from the Cottrell precipitators; the gas absorption and purification plant, and the actual sulphuric acid factory.

(xii) *Miscellaneous.* All internal railway lines, all cars and tubs for the transport of all materials, whether concentrates, ore, fluxes, mattes, bars, ingots, air furnace slag, crusts and scrap, and in general any which may be required for the normal operation of a smelter, and which is not specifically mentioned in sections (i) and (ii).

B. *Description of the smelter*

10. *Capacity* will be initially 100 000 tons of fresh charge; copper concentrates, copper ore and flux. One reverberatory furnace must be capable of handling this tonnage. Future increases will be processed in new furnaces. Smoke ducts to the main smoke stack will be arranged in a manner which will permit connexion at any moment to another furnace, which may commence operation without awaiting the repair of the furnace or furnaces in services.

The construction programme will be divided into the following stages:

1. One reverberatory furnace of 100 000 tons per year;
2. One of 150 000 tons per year;
3. One of 150 000 tons per year.

*Furthermore, space must be provided for the addition of a fourth furnace of 150 000 tons per year.* Consequently, and in accordance with the flow-sheet which is attached to these bases and *which is only illustrative,* the 100 000-ton furnace shown as No. III will be constructed first, followed by the 150 000-ton furnace No. II. Furnace I will be constructed in the third stage, and finally furnace No. IV. The 100 000-ton furnace No. III will be first to be put into operation. *If supplies are sufficient for a greater tonnage, furnace No. III (100 000 tons) will be stopped and the 150 000-ton furnace No. II will be brought into operation. When the prospects are sufficiently favourable for smelting 250 000 tons, the 100 000-ton furnace No. III will be put into service to work in parallel with the 150 000-ton furnace No. II.* The increasing charge which can be smelted each year under this arrangement will be as follows:

| | |
|---|---|
| Furnace No. III | 100 000 |
| Furnace No. II | 150 000 |
| Furnaces II and III | 250 000 |
| etc. | etc. |

11. *Composition of the charge.* The fresh charge which will be smelted in the first stage will have the following approximate percentage composition:

| | *Percentage* |
|---|---|
| Cu | 19.5 |
| $SiO_2$ | 23.1 |
| $Al_2O_3$ | 4.6 |
| Fe | 16.3 |
| CaO MgO | 7.9 |
| S | 17.9 |

The types of ores and concentrates to be smelted will have the following approximate chemical composition and will be charged in the proportions indicated below:

| Type of ore | Proportion in the charge | Cu | $SiO_2$ | $Al_2O_3$ | Fe | CaO + MgO | S |
|---|---|---|---|---|---|---|---|
| | | Percentage | | | | | |
| Sulphide concentrates | 50—60 | 27 | 15 | 3 | 23 | 1 | 28 |
| Oxide concentrates | 5— 7 | 22 | 34 | 3 | 7 | 4 | 7 |
| Oxide ores | 30—35 | 8 | 45 | 10 | 5 | 9 | 3 |
| Lime fluxes | 12—18 | 1 | 16 | 6 | 3 | 40 | 1 |
| Silicon flxes | 6— 8 | 3 | 65 | 8 | 2 | 3 | 1 |

The mineralogical composition of these ores is approximately as follows:

(*a*) *Copper concentrates*: chalconyte predominates ($CuFeS_2$) and certain richer varieties, chalcasite ($Cu_2S$) and bornite ($Cu_5FeS_4$). There is a certain proportion of iron pyrites ($FeS_2$) and some varieties of copper oxides, mainly carbonates ($CuCO_3$ $Cu(OH)_2$).

(*b*) *Copper ores*: In general these are oxides, carbonates and silicates, chrysocolla ($CuSiO_3$ $2H_2O$) and others. The gangue consists of porphyries and more acid rocks.

(*c*) *Lime fluxes*: calcium carbonate ($CaCO_3$) mixed with siliceous gangue.

(*d*) *Siliceous fluxes*: quartzite predominates.

12. The slag will have the following theoretical approximate composition:

| | *Percentage* |
|---|---|
| $SiO_2$ | 40.9 |
| $A_1O_3$ | 8.1 |
| FeO | 37.1 |
| CaO + MgO | 13.9 |

The basicity index, taking alumina as the base, is 1.36. Nevertheless, when calculating the dimensions of the first 100 000-ton furnace, the possibility of smelting a harder charge must be included with a grade of copper of only 15 per cent Cu and a corresponding increase in the amount of silica $SiO_2$ and alumina $Al_2O_3$, so that the slag will be rather more acid and viscose and its volume correlatively greater.

13. The 100 000-ton furnace will have the same width as the others of 150 000 tons but will be lower. From the start the charging platform will have the same height, structure and dimensions as the larger furnaces, and it will be lined up with the rest as shown in the project's flow-sheet. The boilers, smoke chambers and ducts leading to the main smoke stack will have the same dimensions and characteristics as for the large furnaces.

14. *Roasting*. In order to reduce the sulphur content of the charge and use a part of it for the manufacture of sulphuric acid for the electrolytic refinery, a roaster must be installed from the start.

15. To decide the amount of sulphur which may be used in the roasting process for the manufacture of sulphuric acid, it must be remembered that the grade of the matte to be treated in the converters must not be lower than 40 nor higher than 50-per-cent copper.

16. *General layout*. The attached flow-sheet, mentioned in the following paragraphs, is only given for information purposes, so that the author of the project will have no doubts regarding the enterprise's intentions, but in no case does it set a rigid pattern.

17. to 26. Technical details of each of the partial smelter installations.

27. *Omissions and doubts*. Omissions from these bases cannot be accepted as justification for omissions from the project, and in all cases the project-maker must make prior inquiries so that no doubtful point is left unclarified.

## *Case 14*

### ANALYSIS OF TENDERS FOR EQUIPMENT FOR A BEET-SUGAR MILL

A report on the private tenders requested for equipment for a sugar-mill is summarized here. For obvious reasons, neither the country nor the names of the bidders or of the makers of the various items of equipment offered will be given. The other details are complete, including references to specific months.

With the help of the comparative tables, the report enables an appreciation to be made of the type of analysis which may be made when the specifications for the tenders are sufficiently detailed. It also shows the care which must be taken in, and the importance of, specifying equipment when inviting tenders. Without complete specifications it is impossible to compare the bids or to judge them accurately.

In spite of the details requested, it was necessary to make certain additional estimates to compare the final bids fairly. It is easy to understand how much more difficult the task would be if less detailed information were available.

#### 1. *Inviting tenders*

During February the bases were prepared for private tenders for a beet sugar-mill with a daily capacity of 800 000 tons (24-hour operation). The closing date was originally fixed for 21 April, but at the request of some of the bidders it was postponed first to 22 May and later to 22 June, the latter date being final.

Six firms (represented by the letters A, B, C, D, E and F) presented quotations for the complete mill.

#### 2. *Quotations considered*

Table 36 was prepared for the first comparison, showing the most significant aggregate data of the tenders received.

The bidders did not comply strictly with the specifications as regards method of presentation, and it was thus necessary to separate partial prices to make the comparison. In this table it was unfortunately necessary to take total prices for the comparison of the most important equipment, since three bidders did not specify detailed prices and weights, but only total prices.

The total quotations, as presented, are the following:

| *Bidder* | *Dollars* |
|---|---|
| A | 1 871 399 |
| B | 1 990 476 |
| C | 2 299 000 |
| D | 3 325 500 |
| E | 3 325 500 |
| F | 1 792 970 |

#### 3. *First selection*

The prices shown in table 36 are f.o.b. European port. C.i.f. prices may be obtained by adding from 250 000 to 300 000 dollars to the f.o.b. value, according to the bidders. The difference between f.o.b. and c.i.f. was accepted to be approximately the same for all bids, and the prices were compared on an f.o.b. basis. The total prices shown in table 36 are those of the original bids, but are not comparable,

## Table 36

### CASE 14. COMPARISON OF TENDERS OF EQUIPMENT FOR A BEET-SUGAR MILL

*(Dollars)*

| *Name of manufacturer* | F | E | D | B | A | C |
|---|---|---|---|---|---|---|
| *Name of representative* | Q | P | O | N | M | R |
| *Equipment* | | | | | | |
| Sugar plant | +1 544 405 | +2 121 300 | + | +1 402 550 | +1 331 307 | + |
| Cosette dryer | + 54 087 | + 200 500 | + | + 71 028 | + 47 838 | + |
| Caster sugar-mill | + 3 369 | + — | — | — — | — — | — |
| Laboratory | + 11 844 | + 11 700 | + | + 10 000 | + 10 103 | + |
| Sugar warehouse | — — | + 58 000 | —2 232 364 | + 31 200 | + 17 579 | + |
| Workshops | — — | + 108 000 | + | — | — | + |
| *Structure of buildings* | | | | | | |
| Sugar-mill | + 179 265 | + 280 000 | + | + 243 000 | + | +2 299 000 |
| Cosette dryer | — — | + | + | + 32 500 | + | — |
| Sugar warehouse | — — | + 68 000 | — — | + 61 000 | + 277 339 | — |
| Cosette warehouse | — — | — — | — — | — — | + | — |
| Workshops | — — | + 25 500 | — — | + 6 200 | — — | — |
| *Distillery* | | | | | | |
| Equipment | — — | 295 000 | — — | + 86 400 | + 110 939 | + |
| Building | — — | 38 000 | — — | — — | — — | — |
| *Miscellaneous* | | | | | | |
| Installation to produce molasses cosettes | — — | + 19 500 | — — | + 1 940 | + — | — |
| Locomotives and wagons | — — | — — | — — | + 44 650 | + 24 744 | + |
| Spares | — — | — — | — — | — — | + 51 545 | — |
| | 1 792 970 | 3 325 500 | 2 232 364 | 1 990 476 | 1 871 399 | 2 299 000 |
| Total weight in tons | 2 917 | 3 135 | 4 338 | 3 476 | 3 282 | 3 015 |
| Price per ton | 615 | 1 060 | 515 | 573 | 570 | 763 |
| *Delivery period* | 18 months | 16 months | 24 months | 20 months | 12 months | 15 months |
| *Conditions of payment* | 50% immediate<br>50% against delivery | 33% immediate<br>34% in 6 months<br>33% against delivery | 25% immediate<br>20% in 9 months<br>20% in 15 months<br>30% against delivery<br>5% guarantee | 25% immediate<br>25% in 6 months<br>20% in 10 months<br>25% against delivery<br>5% guarantee | 33% immediate<br>34% in 6 months<br>28% against delivery<br>5% guarantee | 25% immediate<br>20% in 6 months<br>25% in 12 months<br>25% against delivery<br>5% guarantee |
| *Deferred payment facilities* | None | 80% credit in 5 years, with 5.7% interest | None | 45% credit in 2½ years with 8% interest | 45% credit in 4½ years with 8.5% interest | None |
| *Guarantees* | | | | | | |
| Material | Yes | Yes | — | Yes | Yes | — |
| Capacity 800 tons daily | Yes | Yes | — | Yes | Yes | — |
| Plant steam consumption | 57 kg steam/100 kg. | 52 kg/100 kg | — | 50 kg/100 kg | 50 kg/100 kg | — |
| Boiler efficiency | 75% | — | — | 80-82% | 80-84% | — |
| Moisture in pressed cosettes | — | — | — | — | 17% | — |
| Coal consumption of dryer | — | 60 kg coal/100 kg | — | 48 kg/100 kg | 49 kg/100 kg | — |
| | | | | Distillery capacity 45 hl per day | Only 3% less difference. | General operation |
| Others | — | Distillery capacity 200 hl in 24 hrs | — | | Distillery capacity 60 hl daily, including insulating and refractory materials and lighting | Distillery 50 hl per day |

(+) Included in tender.
(—) Not included in tender.

since, as may be seen from the same table, there are items which were not quoted by all manufacturers, e.g., the alcohol distillery, which has the greatest capacity in the bid by E. Nevertheless, the largest item, the sugar-mill, may be compared (discounting, as may be seen from the table, the cosette dryers, buildings, distillery, and others).

From this first comparative criterion, the lowest priced are A, B and F. The figure for C cannot be considered, since the mill is not itemized. Nevertheless, by examination of the items quoted separately by C and on the basis of an estimated value of the remaining partial items, compared with other bids—the only available criterion—it may be estimated that the cost of the mill—discounting the items already mentioned—in bid C is between 1.7 and 1.8 million dollars. Similar comparisons may be made for D. On the other hand, C and D did not offer deferred payment terms nor special guarantees on the consumption of coal or steam. Further more, the factory D, according to the specifications and plans, offered an older type of equipment.

C and D were therefore the first to be eliminated.

Although in first place as regards the total price quoted, F was also eliminated. Firstly its price for the sugar-mill was higher than that of A or B. Again, the specifications were not complete and there were no partial quotations, so that a closer comparison could not be made. In any case, according to the specifications received from F it could be seen, for instance, that the carbon dioxide pump was projected for steam operation, while the remainder of the installation was electric, the cosette pressing was in two stages; the evaporation surface area was insufficient and much less than in other bids; the centrifugal crystallizer installation was inadequate and the cooling incomplete. There was no plant for filtering or clarifying the diluted juices from the sugar of the second and third product; the turbo-generator was proposed for 750 kW, while the remainder offered 1 000 kW or over. All these points were sufficient to eliminate F, which was obviously inferior to A and B in quality and price.

In spite of its higher total price, E remained in the first selection since it covered a modern mill, and included complete and detailed specifications.

### 4. *Second selection*

From the entirely technical point of view, the three best offers were A, B and E. These three bidders also offered deferred payments terms (4 and 5 years). Table 37 makes a more detailed comparison of these three bids, and they are summarized in table 38. The total values in this latter table are not the same as in table 36 because table 38 (summary of table 37) only includes those items which were quoted by all three bidders, so as to permit a strict comparison.

As may be seen from table 38, the bid from E is much higher than the other two. Added to this disadvantage, E based its tender on only two final products, the higher production of raw sugar and molasses being compensated by a distillery of higher capacity. An equipment layout for working with three end products increases the cost of the actual sugar equipment, but that of the distillery decreases. From the point of view of mill operation, it is simpler to work with three end products as offered by A and B; this gives more sugar and less alcohol than with two end products. These considerations proved E to be definitely inferior to A and B.

### 5. *Third selection*

The third selection was reduced to the choise between bidders A and B. For the final comparison, table 39 (summarized in table 40) was prepared, including the equipment quoted by each manufacturer and all items considered necessary for the complete sugar-mill were added to both tenders.

In other words, the total values in table 39 are the true cost of each plant if the contract were awarded to either bidder.

The final results were:

| | *Dollars* |
|---|---|
| Total cost of equipment B . . . | 2 172 376 |
| Total cost A . . . . . . . . . | 1 963 372 |

A clear advantage was thus shown for A. To this must be added the fact that this manufacturer offered a continuous diffusion system, guaranteeing a smaller loss of sugar by this process.

### 6. *Changes in price*

The above quotations are the prices offered by the bidders when presenting their tenders, that is, in June. A change in price was anticipated during the intervening period, and a new quotation was therefore requested from the three bidders in the final selection.

The result of the new information was:

| | *Percentages* |
|---|---|
| Increase in equipment E. . . . . | 25 |
| Increase in equipment B. . . . . | 17 |
| Increase in equipment A. . . . . | 19 |

The greater increase in the case of A did not change its advantage over B, and therefore A continued to be the best tender as regards price, with the additional technical advantage of continuous diffusion.

The new prices for complete plants, as explained under 5, would be the following:

| *Bidder* | *Dollars* |
|---|---|
| A | 2 541 680 (up to 31 December 1951) |
| B | 2 336 413 (up to 30 November 1951) |

### 7. *Maximum price adjustment*

All tenders contained price adjustment clauses, based on changes in the prices of raw materials and wages. The two closest bidders (A and B) were requested to specify these adjustments precisely, and to give ceilings.

B indicated the method for price adjustment, but would not accept a ceiling.

A specified adjustment based on official statistics and a ceiling of 14 per cent, and later offered to reduce the ceiling in a cable sent on 26 November. In the same cable A offered to reduce the delivery period (originally 12 months). This latter offer was conditional upon a decision being reached before 30 November.

### 8. *Deferred payment facilities*

B offered deferred payment for 45 per cent of the value up to 30 months after the delivery of the equipment.

## CASE 14. DETAILED COMPARISON OF THE MOST COMPLETE TENDERS OF EQUIPMENT FOR A BEET-SUGAR MILL

*(Prices in dollars)*

| | Tender E | | | Tender B | | | Tender A | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. | Details | Price | No. | Details | Price | No. | Details | Price |
| *Beet reception and storage* | | | | | | | | | |
| Railway weighbridges | 1 | 50 ton capacity | 11 000 | 1 | 50 ton capacity | 5 960 | 1 | 50 ton capacity | 4 454 |
| Lorry weighbridges | 1 | 15 ton capacity | | 1 | 15 ton capacity | 1 460 | 2 | 15 ton capacity | 5 129 |
| Wide gauge diesel locomotives | — | — | | 1 | 107 HP | 16 900 | 1 | 75 HP | |
| Narrow gauge diesel locomotives | — | — | | 1 | 50 HP | 12 950 | 1 | 35 HP | 24 744 |
| Narrow gauge wagons | — | — | | 20 | steel chassis only | 14 800 | 10 | tipping wagons | |
| Dry unloading for vehicles | 1 | complete installation | 101 000 | 1 | installation | 45 100 | 1 | installation | 95 470 |
| Railway unloading | 1 | complete installation | | 1 | complete installation | 6 890 | 1 | complete installation | 8 273 |
| Installation for emptying silos of beet | 5 | silos, w/out pr. pip | 21 000 | 2 | silos w/out pr. pip. | 7 100 | 2 | silos with piping | 22 630 |
| Water discharge pump | 2 | 5 000 litres/min | | 1 | 6 000 litres/min | 2 400 | 2 | 5 000 litres/min. | 2 768 |
| Grass separator | | | | 1 | complete installation | 2 900 | 1 | complete installation | 2 598 |
| | | | 133 000 | | | 116 050 | | | 166 066 |
| *Preparation* | | | | | | | | | |
| Lifting | 1 | wheel lift 8 m. φ | 69 000 | 1 | wheel lift 7.3 m. φ | 8 100 | 1 | pump with water sep. | 12 119 |
| Washer | 1 | 1.5 m. wide, 9 m. long | | 1 | 1.65 m. by 9 m. long | 11 550 | 1 | 1.80 m. by 10 m. long | 15 314 |
| Conveyor | 1 | complete installation | | 1 | complete installation | 1 915 | 1 | complete installation | 4 145 |
| Hoist | 1 | complete installation | | 1 | complete installation | 9 270 | 1 | complete installation | 7 165 |
| Root treatment | — | — | | 1 | complete installation | 7 760 | 1 | complete installation | 7 722 |
| Distributor | 1 | complete installation | 50 000 | 1 | complete installation | 2 680 | 1 | complete installation | 1 876 |
| Automatic beet platform scale | 1 | 500 kg. | | 1 | 600 kg. | 4 770 | 1 | with print. rec. tape | 7 165 |
| Complete cutting machine | 2 | 2 200 mm. diam. ea. | | 2 | 2 000 mm. diam. ea. | 17 770 | 2 | 1 800 mm. diam. ea. | 15 925 |
| | 1 | complete installation | | 1 | complete installation (12.5 ton) | 8 200 | 1 | complete installation (16 ton) | 10 774 |
| | | | 119 000 | | | 72 015 | | | 82 236 |
| *Extraction* | | | | | | | | | |
| Complete diffusion system | 1 | standard installation 14 diff. 80 hlt. ea. | 168 000 | 1 | standard installation 12 diff. 85 hlt. ea. | 68 265 | 1 | continuous installation | 86 449 |
| | | | 168 000 | | | 68 265 | | | 86 449 |
| *Pulp presses* | | | | | | | | | |
| Belt conveyor for fresh cosettes | 1 | complete installation | 70 000 | 1 | complete installation | 14 800 | 1 | complete installation | 3 247 |
| Presses | 2 | vertical up to 12% m. | | 3 | vert. up to 16% m. | 24 900 | 2 | vert. up to 17% m. | 13 403 |
| Belt conveyor for pressed cosettes | 1 | complete installation | | | | | 1 | complete installation | 5 258 |
| | | | 70 000 | | | 39 700 | | | 31 908 |
| *Purification* | | | | | | | | | |
| Liming tanks | 1 | continuous installation | | 1 | continuous installation | 15 505 | 1 | continuous installation | 12 552 |
| Carbonation | 2 | continuous installation | | 2 | continuous installation | 14 735 | 2 | continuous installation | 10 360 |
| Sulphitation | 1 | complete installation 3 f. | | 1 | complete installation 4 | 2 435 | — | — | |
| Juice heaters | 5 | 1.80 m², 4.60 m² ea. | 190 000 | 9 | 50 m² each | 22 795 | 7 | 60 m² each | 14 289 |
| Filter-presses | 7 | 84 m² each | 23 300 | 7 | 4:100 m²; 3:54 m² ea. | 62 365 | 6 | 110 m² each | 87 836 |
| Bag filters | 4 | 52 m² each | 23 000 | 12 | 33 m² each | 25 040 | 8 | 50 m² each | 9 279 |
| Char treatment | 1 | complete installation | | 1 | complete installation | 4 435 | 1 | complete installation | 2 923 |
| Fibre washer | 1 | complete installation | | 1 | complete installation | 1 170 | 1 | complete installation | 2 206 |
| Juice pumps | 8 | miscellaneous | | 11 | miscellaneous | 6 205 | 14 | miscellaneous | 12 841 |
| | | | 236 300 | | | 154 685 | | | 152 286 |

| | | | |
|---|---|---|---|
| *Evaporation* | | | |
| Clear juice heater | 1 | 60 m² each | |
| Evaporators | 4 | 2 050 m² | |
| Viscosity gauges | — | — | 120 000 |
| Condensed water t. | 1 | complete installation | |
| Condensed water pump | 3 | complete | |
| | | | 120 000 |
| *Crystallization and separation* | | | |
| Vacuum pans | 3 | 250 hlt. 170 m² ea. | |
| Coolers | 7 | complete | |
| Centrifugal crystallizers | 5 | 1 065 mm. d. semi. aut. | |
| Granulated sugar treatment | 1 | complete installation | 234 000 |
| Washed sugar treatment | — | — | 39 000 |
| Diluted juice treatment | — | — | 25 000 |
| Condensers, including air pump | 1 | complete installation w/1p. | |
| Pump for syrup and boiled material | 8 | miscellaneous | |
| Miscellaneous tanks | | miscellaneous | |
| | | | 298 000 |
| *Lime manufacture:* | | | |
| Lime kiln | 1 | 65 m.³ not aut. w/out. r. | |
| Lime treatment | 1 | complete installation | 80 000 |
| Washer and gas piping | 1 | complete installation | |
| Gas pump | 1 | complete installation w/1p. | |
| | | | 80 000 |
| *Boiler house* | | | |
| Boiler with economizers | 2 | 19 ton steam/hr. ea. | |
| Smoke draught installation | 2 | complete installation | |
| Coal feeder | 1 | complete installation | |
| Water tank | 2 | 20 m³ each | |
| Steam cooler | — | — | 310 000 |
| Control panel | — | — | |
| Insulating materials | — | — | |
| Refractories | — | — | |
| Feed pumps | 2 | 1 w/elect. mot. & 1 dup. | |
| | | | 310 000 |
| *Power house* | | | |
| Turbo-generator | 2 | 800 kW each | |
| Transformer | — | — | 187 000 |
| Distribution board | 1 | 6 panels | |
| Cabling to switchboard | | complete | |
| Cabling to motors | | complete | |
| Lighting | | complete | 98 000 |
| Electrical installation | | complete | |
| Motors (electric) | | included above | |
| | | | 285 000 |
| *Miscellaneous* | | | |
| Tubing for entire plant | | complete | |
| Molasses tank, pump, etc. | | miscellaneous | 302 000 |
| Insulting material, gen. | — | — | |
| | | | 302 000 |

NOTE: pr.pip. = pressure piping; 12%m. 12% moisture; 3f. = filters; w/out. r. = without refractories;

| | | | | | |
|---|---|---|---|---|---|
| 2 | 50 $m^2$ each | 4 865 | 2 | 60 $m^2$ each | 4 083 |
| 4 | 1 500 $m^2$ | 47 650 | 4 | 1 600 $m^2$ | 41 276 |
| 2 | | 925 | — | — | |
| 1 | complete installation | 4 800 | 1 | complete installation | 4 423 |
| 2 | 800 litre/min each | 390 | 3 | 600 litre/min each | 1 423 |
| | | 58 630 | | | 51 205 |
| 5 | 250 *hlt.* *160* $m^2$ ea. | 55 200 | 4 | 225 *hlt.* and *165* $m^2$ | 43 303 |
| 9 | complete | 42 385 | 6 | complete | 32 126 |
| 12 | 1 065 mm. d. demi. aut. | 99 805 | 10 | 1 250 mm. d. ea. autom. | 90 215 |
| 1 | complete installation | 30 940 | 1 | complete installation | 19 629 |
| 1 | complete installation | 3 670 | 1 | complete installation | 1 443 |
| 1 | complete installation | 21 780 | 1 | complete installation | 6 685 |
| 1 | complete installation, 2 pumps | 20 270 | 1 | complete installation, 2 pumps | 20 290 |
| 21 | miscellaneous | 15 155 | 10 | miscellaneous | 8 367 |
| | miscellaneous | 23 885 | | miscellaneous | 10 887 |
| | | 313 090 | | | 232 945 |
| 1 | 50 $m^3$ aut. w/out. r. | 41 690 | 1 | 40 $m^3$ aut. with ref. | |
| 1 | complete installation | 10 180 | 1 | complete installation | |
| 1 | complete installation | 5 395 | 1 | complete installation | 64 595 |
| 2 | 29 $m^3$/min. | 18 000 | 1 | 30 $m^3$/min. | |
| | | 66 265 | | | 64 595 |
| 2 | 24 ton steam/hr. | 211 000 | 1 | 25 ton steam/hr. | |
| — | — | | 1 | complete installation | |
| 1 | complete installation | 22 300 | 1 | complete installation | |
| 1 | 35 $m^3$ | 4 000 | 1 | 50 $m^3$ | |
| 1 | complete installation | 3 860 | 1 | complete installation | 158 774 |
| 1 | complete installation | 5 950 | 1 | complete installation | |
| — | — | | | complete | |
| — | — | | | complete | |
| 2 | 1 elect. mot., 1 turb. | 6 650 | 2 | with elec. mot. & turb. | |
| | | 253 760 | | | 158 774 |
| 1 | 1 050 kW | 65 120 | 1 | 1 000 kW | 59 798 |
| 1 | 200 kVA | 1 630 | — | — | |
| 1 | 10 panels | 21 300 | 1 | 10 panels | 17 836 |
| | | | | complete | |
| | | | | complete | |
| | | | | complete | 61 860 |
| | complete | 5 335 | | complete | |
| | miscellaneous | 48 114 | | miscellaneous | 18 558 |
| | | 141 499 | | | 158 052 |
| | complete | 125 000 | | complete | 129 986 |
| | miscellaneous | 38 000 | | miscellaneous | 10 699 |
| — | — | | | complete | 30 930 |
| | | 163 249 | | | 171 535 |

with ref. = with refractories; w/1 p. = with 1 pump.

**Table 38**

CASE 14. SUMMARY OF TABLE 37

*(Prices in dollars)*

| | Tender E | | Tender B | | Tender A | |
|---|---|---|---|---|---|---|
| | Details | Price | Details | Price | Details | Price |
| *Sugar-mill equipment* | | | | | | |
| Reception and storage | | 133 000 | | 116 050 | | 166 071 |
| Preparation | | 119 000 | | 72 015 | | 82 236 |
| Extraction | Without | 168 000 | Without | 68 265 | With | 86 449 |
| Cosette pressing | Locomotive and wagons | 70 000 | Insulating material | 39 700 | Insulating material | 31 908 |
| Purification | Insulating materials | 236 300 | Refractories | 154 685 | Refractories | 152 286 |
| Evaporation | Refractories | 120 000 | Cabling | 58 630 | Cabling | 51 205 |
| Crystallization and separation | | 298 000 | Lighting | 313 090 | Lighting | 232 945 |
| Lime manufacture | With | 80 000 | | 66 265 | Locomotive and wagons | 64 595 |
| Boiler house | Cabling | 310 000 | With | 253 760 | | 158 774 |
| Power house | Lighting | 285 000 | Locomotive and wagons | 141 499 | | 158 052 |
| Miscellaneous | | 302 000 | | 163 249 | | 171 535 |
| | | 2 121 300 | | 1 447 208 | | 1 356 056 |
| *Other equipment* | | | | | | |
| Pulp dryer | 2 tanks, 2.25 m. $\phi$, 14 m. lg. | 200 500 | 1 tank 2.40 m. $\phi \times$12 m. lg. | 71 028 | 1 tank., 2.20 $\phi \times$12 m. lg. | 47 838 |
| Sugar warehouse | Complete installation | 58 000 | Complete installation | 31 200 | Complete installation | 17 579 |
| Complete distillation | 200 hlt daily capacity | 295 000 | 45 hl daily capacity | 86 400 | 60 hl capacity | 110 939 |
| *Building construction* | | | | | | |
| Plant, boiler house, power house, lime kiln | 3 185 m² | | 4 600 m² | | 3 700 m² | |
| Dryer | 600 „ Total | | 600 „ Total | | 600 „ Total | |
| Sugar warehouse | 250 „ 4 035 m² | 348 000 | 2 200 „ 7 400 m² | 342 700 | 1 500 „ 6 400 m² | 277 339 |
| Dry pulp warehouse | — „ | | — „ | | 600 „ | |
| *Total price, equipment and building* | | 3 022 800 | | 1 978 536 | | 1 809 750 |
| Weight supplied in tons | | 2 940 | | 3 476 | | 3 282 |
| Price per ton in dollars | | 1 012 | | 569 | | 551 |
| *Technical guarantees* | | | | | | |
| Material | Yes | | Yes | | Yes | |
| Capacity | 800 tons beet daily | | 800 tons beet daily | | 800 tons beet daily | |
| Steam consumption | 52-53 kg steam/100 kg beet | | 60 kg steam/100 kg beet | | 50 kg/100 kg beet | |
| Moisture, pressed | — | | — | | 17 per cent | |
| Coal consumption of dryer | 60-61 kg coal/100 kg pulp dried | | 48 kg coal/100 kg of pulp to 16% moisture | | 47-50 kg coal/100 kg pulp | |
| Boiler efficiency | — | | 80-82% | | 80-84% | |
| Loss of sugar in diffusion | — | | — | | 0.3 per cent sugar | |

Table 39

## CASE 14. COMPARISON OF THE TWO BEST TENDERS, WITH THE ADDITION OF EQUIPMENT NOT INCLUDED BUT CONSIDERED NECESSARY FOR A BEET-SUGAR MILL[a]

*(Prices in dollars)*

| | Tender A | | | | Tender B | | | |
|---|---|---|---|---|---|---|---|---|
| | *Location in tender* | *No.* | *Size, capacity, weight* | *Price* | *Location in tender* | *No.* | *Size, capacity, weight* | *Price* |
| *Factory equipment-Reception* | | | | | | | | |
| Railway weighbridge | 1a | 1 | 50 ton, safety device number | 6 550 | 3 | 1 | 50 tons with saf. and numb. dev. | 4 454 |
| Lorry weighbridge | 2a | 1 | 15 ton, safety device number | 2 000 | 1 | 2 | 15 tons with saf. and numb. dev. | 5 129 |
| Wide gauge diesel locomotive | 3 | 1 | 107 HP | 16 900 | 137 | 1 | 75 HP. | |
| Narrow gauge diesel locomotive | 4 | 1 | 50 HP | 12 950 | 137 | 1 | 39 HP. | 24 744 |
| Narrow gauge wagons | 5 | 20 | Steel chassis only, w/out wood | 14 800 | 137 | 10 | Tipping wagons | |
| Dry unloading | 7 | 2 | Silos, only 18 tons of piping | 7 100 | 5 | 2 | Silos, 40 tons of piping | 22 630 |
| Dry unloading, railway | 8 | 1 | Complete installation | 6 890 | 4 | 1 | 5 000 l itres/min. with piping | 2 768 |
| Water pump | 10a | 1 | 6 000 Litres/min. w/out piping | 2 400 | 96 | 2 | 5 000 l./min. with piping | 2 768 |
| Grass separator | 11 | 1 | Triangular (delta) | 2 490 | 6 | 1 | Square | 2 593 |
| | Plus | 3 | Silos with 27 tons of piping | 10 650 | Plus | 20 | Wagons | 14 800 |
| | | | 100 tons pressure (estimated) | 40 000 | | 3 | Silos with 60 tons piping | 33 945 |
| | | 10 | Tipping wagons | 3 000 | | | | |
| | | 1 | water pump | 2 400 | | | | |
| | | 1 | Lorry weighbridge | 2 000 | | | | |
| | | | | 138 680 | | | | 119 336 |
| *Preparation* | | | | | | | | |
| Beet pump | 13 | 1 | Weight 7 tons | 11 750 | 7 | 1 | Weight 6.8 tons | 11 568 |
| Water separator | | 1 | Weight 1.2 tons (estimated) | 550 | 8 | 1 | Weight 1.2 tons | 561 |
| Washer | 14 | 1 | 1.65 m wide, chain 23 mm diam | 11 550 | 9 | 1 | 1.80 m wide, 10 m long | 15 341 |
| Conveyor | 15 | 1 | Weight 3 tons | 1 915 | 10 | 1 | Weight 7.5 tons; worm | 4 145 |
| Hoist | 16 | 1 | 500 mm wide, chain 23 mm diam | 9 720 | 11 | 1 | Buck. with 500 mm, chain 23 mm d. | 7 165 |
| Root treatment | 17-23 | 1 | With pump | 7 760 | 13 | 1 | With pump | 7 722 |
| Distributor | 24-26 | 1 | Weight 5.6 tons | 2 680 | 12 | 1 | Weight 4.5 tons, cap. 35 $m^3$ | 1 876 |
| Automatic platform scale | 25 | 1 | 600 kg | 4 770 | 15 | 1 | Automat. for cosset. reg. valve f/c. | 7 165 |
| Slicer | 27-31 | 2 | 2 000 mm diam complete with pan | 16 360 | 14 | 2 | 1 800 mm diam, complete | 15 929 |
| Blade sharpener | 32-33 | 2 | Machines | 1 410 | 14 | 2 | Machines | 15 929 |
| | | | | 68 465 | | | | 71 462 |
| *Extraction* | | | | | | | | |
| Conveyor, fresh cosettes | 34-35 | 1 | Band weight 12.5 tons | 8 200 | 16-18 | 3 | Hot screw, 16.4 tons | 10 774 |
| Complete diffusion | 36-39 | 1 | Classical battery, 12 diffusers 85 hit each | 68 265 | 19 | 1 | Continuous "Torre" system | 86 449 |
| | | | | 76 485 | | | | 97 223 |
| *Used cosette pressing* | | | | | | | | |
| Conveyors | 40-49 | 1 | Band, pump, etc. | 14 800 | 20 | 1 | Belt conveyor | |
| Automatic platform scale | — | 1 | System | 3 765 | 20 | 1 | Special tape weigher | 7 047 |
| Presses | 46 | 3 | Weight 30 tons | 24 900 | 21 | 3 | Weight 28.1 tons | 20 140 |
| | | | | 43 465 | | | | 27 187 |

*Continued*

**Table 39 (Continued)**

| | Tender B | | | | Tender A | | | |
|---|---|---|---|---|---|---|---|---|
| | *Location in tender* | *No.* | *Size, capacity, weight* | *Price* | *Location in tender* | *No.* | *Size, capacity, weight* | *Price* |
| *Purification* | | | | | | | | |
| Liming-tanks | 68-72-205 | 1 | Cont. with lime cream, 25.5 t. | 15 505 | 23,24 | 1 | Cont. with quick lime, 22.3 t. | 12 552 |
| 1st. carbonation | 73, 74 | 1 | Cont. installation | 7 535 | 26-27 | 1 | Cont. inst. with HP aut. reg. | 5 175 |
| 2nd. carbonation | 76 | 1 | Cont. system | 7 200 | 33, 34 | 1 | Cont. inst. with HP aut. reg. | 5 180 |
| Sulphitation | 77, 78, 80 | 1 | Cont. installation | 2 435 | — | 1 | Cont. installation | 1 650 |
| Juice heater | 98-102 | 11 | 12 circulations, 50 m² | 27 660 | 25, 28, 32, 40 | 9 | 12 circulations 60 m² | 18 372 |
| Hydraulic press filters | 81-84-7 | 7 | 4 of 100 m² and 3 of 54 m² | 62 365 | 29, 35 | 6 | 110 m² (automatic) each | 87 836 |
| Bag filters | 89-94, 111, 112 | 16 | Filter area 33 m² each | 25 040 | 30, 36, 46 | 11 | Filter area 50 m² each | 12 817 |
| Char treatment | 86, 87 | 1 | Complete instal. with pump | 4 435 | 38, 103 | 1 | Complete instal. with pump | 2 923 |
| | | | | 152 175 | | | | 146 502 |
| *Evaporation* | | | | | | | | |
| Evaporators | 103, 104 | 1 | Quadruple, 1 500 m² heat. surf. | 47 650 | 41, 42 | 1 | Triple 1 600 m² heat. surface | 41 276 |
| Density meters | 105 | 2 | Manufacturer named | 925 | — | 2 | | 1 450 |
| Condensed water tanks | 106, 107 | 1 | Weight 9.6 tons | 4 800 | 43, 44 | 1 | Weight 6.6 tons | 4 423 |
| | | | | 53 375 | | | | 46 629 |
| *Crystallization and separator* | | | | | | | | |
| Vacuums pans | 115, 141, 161 | 5 | 4 of 160 m², 1 of 120 m² | 55 200 | 48, 57, 68 | 5 | 165 m² heating surface | 54 128 |
| Coolers | 116, 142, 162, 163 | 9 | Standard | 42 385 | 49, 58, 69, 70 | 6 | 1 special, 4 standard | 32 126 |
| Centr. cryst. w. m. 119, 122, 144, 145 | 165, 166, 222, 223 | 12 | For 350 kg; 1 065 mm. d. semi-aut. | 103 405 | 51, 61, 73 | 10 | 4 500 kg, 6-350 kg. fully aut. | 90 315 |
| Gran. sug. treat. 123-16. | 129-123, 136, 138 | 1 | Weight 44.6 tons | 32 060 | 52-55, 76-79 | 1 | Weight 21.3 tons | 18 287 |
| Platform scales for sugar | 134 | 3 | Automatic | 1 065 | 80 | 3 | Automatic | 1 340 |
| Treatment of washed sugar | 147, 167, 168 | 1 | Complete installation | 3 670 | 74 | 1 | Complete installation | 1 443 |
| Treatment of diluted juices | 148, 149-154, 172 | 1 | Complete inst. with filter press | 22 705 | 59, 63-65 | 1 | Complete inst. with bag filter | 10 320 |
| Molasses platform scales | — | 1 | Automatic | 2 455 | — | 1 | Automatic | 2 700 |
| | | | | 262 945 | | | | 210 659 |
| *Condensation* | | | | | | | | |
| Juice separator | 176 | 2 | Weight 6.0 tons | 3 200 | 83 | 1 | | 2 232 |
| Condensers | 177 | 2 | Weight 6.0 tons | 3 320 | 83 | 1 | Weight 7.0 tons | |
| Air pumps | 178 | 2 | 30 m³/min. ea. incl. elect. motor | 13 750 | 85 | 2 | 35 m³/min. ea. with elect. motor | 18 558 |
| | | | | 20 270 | | | | 20 790 |
| *Lime making* | | | | | | | | |
| Lime klin | 50-55, 59 | 1 | 50 m³ incl. refract. 135 tons | 41 690 | 86, 87 | 1 | 40 m³ incl. refract. 175 tons | 64 592 |
| Lime treatment | 60-65 | 1 | Weight 12.6 tons | 10 180 | 92, 95 | 1 | | |
| Gas washer and piping | 56-58 | 1 | Weight 8.9 tons | 5 395 | 88-89 | 1 | | |
| Gas pump | 187 | 2 | 29 m³/min.ea. 5.0 tons | 15 000 | 90, 91 | 2 | 30 m³/min. ea. | |
| | | | | 72 265 | | | | 64 592 |
| *Boiler house* | | | | | | | | |
| Boilers with economizers | 207 | 2 | 24 tons steam/hr. ea. 25 atm. 350°C | 211 000 | | 3 | 12.5 t. steam/hr. ea. 28 at. 400°C (68 000 ea.) | 250 274 |
| Exhauster installation | 208 | 1 | Complete installation | 13 400 | | 3 | Complete installation | |
| Water feed pump | 210 | 2 | 1 with elect. motor, 1 with st. turb. | 6 650 | | 2 | 1 with motor, 1 with turbine | |
| Coal feeder or stoker | 212 | 1 | Complete inst. with auto. weigher | 22 300 | | 1 | Complete inst. with aut. weigh. | |
| Water tank | 213 | 1 | Volume 35 m³ | 4 000 | 132 | 1 | 50 m³ volume | |
| Steam cooler | 209 | 2 | Complete installation | 3 860 | | 2 | Complete installation | |
| Control panel | 211 | 1 | Complete installation | 5 950 | | 1 | Complete installation | |
| Refractories | — | 1 | (Estimated) | 25 000 | | 1 | Complete installation | |
| Insulation material | — | 1 | (Estimated) | 12 000 | | 1 | Complete installation | |
| | | | | 304 160 | | | | 250 274 |

| | | | |
|---|---|---|---|
| *Power house* | | | |
| "NN" turbo-generator | 214-216 | 1 | 1 600 kVA, 400 volt, 5 000 rpm |
| Distribution panel | 217 | 1 | With ten complete panels |
| Cabling, generator-panel | 219 | 1 | Compl. (est. bidder) |
| Cabling, panel-motors | 219 | 1 | Complete (est. bidder) |
| Elect. instal. (switches, etc.) | 218 | 1 | Complete |
| Lighting installation | 220 | 1 | Complete |
| Electric motors | 221 | 1 | All (except cryst. and pump) |
| Travelling crane | 203 | 1 | Weight 12 tons |
| *Miscellaneous* | | | |
| Pumps | Various | 1 | Complete installation |
| Tanks | Various | 1 | Weight 50.6 tons |
| Molasses tank | 174 | 1 | *1 000 $m^3$ 32.7 tons* |
| Filter cloth washer | 200 | 1 | Weight 1.1 tons |
| Filter sewing machine | 202 | 1 | Complete installation |
| Piping | 195 | 1 | Approx. 180 tons |
| Chutes and channels | 196 | 1 | Approx. 12 tons |
| Various | 183 | 1 | Weight 0.7 tons |
| Pipe insulating materials | 198 | 1 | Complete (estimated) |
| *Other equipment dryer* | | | |
| Conveyor, wet cosettes | — | 1 | Complete inst. 10.5 tons |
| Drying drum | 234-249, 253 | 1 | 2 400 mm diam. 12 m long |
| Conveyor, dry cosettes | 234-249, 253 | 1 | Without scale |
| Molasses mixer | 250-252 | 1 | Complete installation |
| Air conveyor to warehouse | 258 | 1 | Complete inst. less blower |
| *Sugar warehouse* | | | |
| Sack conveyor | — | 1 | 60 m long, 7.2 tons |
| Warehouse installation | — | 2 | Hoist |
| *Distillery* | | | |
| Complete installation | — | 1 | 45 hlt alcohol/24 hours |
| *Mill for grinding caster sugar* | 139 | 1 | Complete installation |
| *Steel structures of buildings* | | | |
| Sugar plant | 225, 227, 228, 229, 231 | | Approx. 4 600 $m^2$ |
| Dryer | 230 | | Approx. 600 $m^2$ |
| Sugar warehouse | 226 | | Approx. 2 200 $m^2$ |
| Dry cosettes warehouse | — | | Approx. 600 $m^2$ |

[a] The prices of this additional equipment have been taken from the supplies themselves; in those cases where tl
cryst. w. m. = centrifugal crystallizers with motor; gran. sug. treat. = granulated sugar treatment.

| | | | | |
|---|---|---|---|---|
| 65 120 | 133 a, b | 1 | 1 600 kVA, 230/400 volt, 6 000 rpm | 59 798 |
| 21 300 | 133 c | 1 | 10 complete panels | |
| 10 000 | | 1 | Complete installation | 17 836 |
| 30 000 | 119 | 1 | Complete installation | |
| 5 335 | 120, 121 | 1 | Complete installation | |
| 20 000 | 122 | 1 | Complete installation | 61 860 |
| 45 228 | 118 | 1 | All (except cryst. and pump) | 10 800 |
| 10 300 | — | 1 | | |
| | | | | 168 854 |
| 207 283 | | | | |
| 23 270 | 96-117 | 1 | Complete installation | 35 435 |
| 24 010 | Various | 1 | Weight 24.4 tons | 9 305 |
| 7 300 | 125 | 1 | *900 m³, 32 tons* | 8 660 |
| 1 170 | 123 | 1 | Weight 1.8 tons | 2 206 |
| 430 | — | 1 | Complete installation | 740 |
| 125 000 | 129 | 1 | Compl. inst. approx. 180 tons | |
| 5 400 | 129 | 1 | Complete installation | 129 906 |
| 1 220 | 129 | 1 | Various | |
| 35 000 | 130 | 1 | Complete | 30 930 |
| 222 800 | | | | 217 182 |
| 6 870 | 22 | 1 | Complete inst. w/9-ton aut. weight | 9 058 |
| 68 308 | 131 | 1 | 2 200 mm diam. 11 m long | 47 838 |
| | 131 | 1 | Compl. inst. w/2 aut. plat. scales | |
| 1 700 | — | 1 | Complete installation | 1 700 |
| 3 660 | — | 1 | Complete installation | 9 050 |
| 9 000 | 82 | 1 | 60 m long, 14.5 tons | 15 671 |
| 5 220 | 81 | 2 | hoists | 3 814 |
| 86 400 | — | 1 | 60 hlt alcohol/day | 110 939 |
| 3 550 | — | 1 | Complete installation | 3 780 |
| 184 708 | | | | 201 850 |
| 249 200 | — | | Approx. 4 700 m² | |
| 32 500 | — | | Approx. 600 m² | 320 839 |
| 61 000 | — | | Approx. 1 500 m² | |
| 22 600 | — | | Approx. 600 m² | |
| 365 300 | | | | 320 839 |

e number of units was increased, the prices were estimated afterwards or on the basis of supplies. centr.

Table 40

CASE 14. SUMMARY OF TABLE 39

*(Dollars)*

| | Tender B | Tender A |
|---|---|---|
| Reception | 138 680 | 119 336 |
| Preparation | 68 565 | 71 462 |
| Extraction | 76 485 | 97 223 |
| Cosette pressing | 43 465 | 27 187 |
| Purification | 152 175 | 146 502 |
| Evaporation | 53 375 | 46 624 |
| Crystallization and separation | 262 945 | 270 659 |
| Condensation | 20 270 | 20 790 |
| Lime making | 72 265 | 64 592 |
| Boiler house | 304 160 | 250 274 |
| Power house | 207 283 | 168 852 |
| Miscellaneous | 222 800 | 217 182 |
| Other equipment | 184 708 | 201 805 |
| Building structures | 365 300 | 320 839 |
| *Total* | 2 172 376 | 1 963 372 |
| Difference | 209 004 | |

The remaining 55 per cent had to be paid during the period between the confirmation of the contract and complete delivery. Interest was to be charged on the balance at 8 per cent annually.

A offered a term of 54 months from the date of the firm order, also for 45 per cent of the value of the equipment. The remaining 55 per cent was to be paid between the date of signing the contract and official delivery. Since the delivery period offered was 12 months, the payment of the 45 per cent was to be deferred for 42 months after delivery. Interest was to be 8.5 per cent annually, with 1.5 per cent commission on the 45 per cent financed, in one final payment.

### 9. *Guarantees*

With the exception of the loss of sugar in diffusion, the guarantees offered by A an B were very similar, consisting of the retention of 5 per cent of the payment until the equipment was in operation, to guarantee performance figures. These figures were:

| | *A* | *B* |
|---|---|---|
| Sugar loss in diffusion (percentage) | 0.3 | — |
| Moisture in pressed cosettes (percentage) | 17 | — |
| Steam consumption per 100 kg of beet | 50 | 50 |
| Coal consumption for drying 100 kg of pressed cosettes[a] | 49 | 48 |
| Boiler efficiency (percentage) | 80—84 | 80—82 |

[a] A guaranteed the moisture in the pulp together with the coal consumption of the dryer. B guaranteed the dryer's coal consumption "always assuming that the pulp contains 16 per cent moisture", but did not guarantee this latter figure.

### 10. *Conclusion*

According to the data, A's tender was the better. Its advantages over the remaining bidders may be summarized as follows:

(*a*) Lower price.

(*b*) It is a modern plant with continuous diffusion, which guarantees less loss of sugar.

(*c*) It has a shorter delivery period (12 months), and A cabled an offer to reduce this.

(*d*) It offers the lowest ceiling for price adjustment. A also cabled an offer to reduce this further if the contract was signed before 30 November.

(*e*) It gives greater deferred payment facilities, although at somewhat higher interest than B (8.5 instead of 8 per cent).

(*f*) It guarantees the lowest steam consumption, equalled only by B.

(*g*) It guarantees the moisture content of the pressed pulp.

### 11. *C.i.f. value, as considered in the project*

It was seen that A's tender gave a price of 2 336 413 dollars, f.o.b. European port, including export packing. Adding the price increase ceiling of 14 per cent, this would give a maximum f.o.b. value of 2.66 million dollars. Allowing 0.34 million dollars for freight and insurance, the maximum c.i.f. value would be 3 million dollars. The project was prepared on the basis of this amount.

This value would be obtained only if the contract was signed at an early date, before the ceiling was raised or before general conditions in Europe changed.

## *Case 15*

## Choice of technical alternatives in the Chilean electrification programme to meet demand in the third geographical region (1953-1964)

### 1. *Present deficit*

The forecasts of maximum demand for electrical energy in the third Chilean geographical region were explained earlier.[4] A summary is given here of the technical analysis which was made to choose the best alternative between the possible power stations in the region. An appendix is added to simplify the text for those readers who are not familiar with the technical aspects. The region is divided into two zones, north and south of the River Maipo, shown as A and B.

In 1953, when the programme was formulated, the peak hourly demand in winter in zone A was 311 000 kW, and 30 000 in zone B, giving a total of 341 000 for the region. The total installed capacity to meet this demand was 338 000 kW, of which the winter base load was estimated at only 289 000 kW, so that there was an initial deficit.

All the existing installed power stations in the region were listed, excluding only those not connected to the distribution grid. Of the latter, it is assumed that industrial stand-by stations would not operate if power were available from the grid. The power station of a mining enterprise operating in the region was omitted, since this mine's demand was also excluded from the consumption.

The list of plants included details of the type (hydroelectric or thermal), the date of installation and power (specifying the number of units and the installed capacity of each plant, total installed power and winter maximum base load, i.e., the maximum power available in winter during periods of maximum demand).

The installation dates show that many of these plants were old. During the project period (1953-1964) they would reach the age of 50 years. Others are uneconomic,

[4] See case 3.

and many should be taken out of service when the supply is adequate. For hydrological reasons, others cannot produce the total of installed power in winter (glacier system of rivers). To sum up, of an installed power of 338 000 kW, 289 000 kW of firm power will be available only if no plant goes out of service for major repairs, assuming that there will be a certain minimum flow simultaneously in the different rivers.[5]

### 2. *Comparison of availability and demand*

The total availability has been divided into the area supplied under a concession to a private company, and the remainder (zones A and B respectively).

Comparing available power with the demand in the zones, it may be seen that zone B has a surplus, while A has a considerable deficit. The magnitude of this deficit has not been felt to its full extent, since a plant in zone B delivers part of its output to zone A.

The base load available in zone A in 1952 came from the private enterprise (154 800 kW) and the interconnected plants of the system (estimated at 41 100 kW). The available total was therefore some 195 000 kW, to which may be added the surplus in zone B. In 1953, the following was the situation in zone A: the transfer of 63 000 surplus kW from zone B was added to the available 195 000 kW, giving a total availability of 260 000 kW against an anticipated demand of 311 000 kW. A deficit of 50 000 KW was therefore foreseen, which could only be reduced in part by the private industrial plants (totalling some 9 500 kW).

The deficit in installed power is only part of the problem; the deficit in energy must also be considered. The latter deficit is caused by periods of extreme drought, when the regulating reservoirs do not accumulate sufficient water to meet the daily peak load and the winter peak power and available energy, which depends upon the flow, are thus reduced.[6]

In zone B new plants are being constructed, which, in addition to ensuring the supply, will deliver their surplus to zone A as previously explained. Including these surpluses, the availability for zone A, consisting of the 195 000 kW produced by the private enterprise plus the inter-connected industrial plants and the surpluses from zone B, will be as shown in table 41.

**Table 41**

CASE 15. DEMAND AND AVAILABILITY OF ELECTRIC ENERGY IN CHILE, ZONE A OF THE THIRD GEOGRAPHICAL REGION, 1951-64

*(Thousands of kW)*

| *Year* | *Peak hourly demand* | *Present availability including works under construction in zone B*[a] |
|---|---|---|
| 1951 | 268.9 | 263.6 |
| 1952 | 291.3 | 261.2 |
| 1953 | 310.8 | 268.8 |
| 1954 | 331.8 | 266.4 |
| 1955 | 354.1 | 356.2 |
| 1956 | 378.0 | 343.2 |
| 1957 | 403.6 | 339.9 |
| 1958 | 431.0 | 345.5 |
| 1959 | 460.3 | 378.8 |
| 1960 | 491.7 | 374.7 |
| 1961 | 525.3 | 370.2 |
| 1962 | 561.2 | 365.4 |
| 1963 | 599.8 | 360.2 |
| 1964 | 641.0 | 354.4 |

[a] The availability decreased because the surpluses of zone B, which are transferred to zone A, are declining. The word "present" refers to the date of the study.

### 3. *Capacity to be installed*

The availability shown in table 41 includes all plants, existing and under construction, except the small plants belonging to industries which cannot be connected to the system. As from 1958, the availability will be definitely insufficient, and between 1956 and 1964 a minimum of 300 000 kW must be put into service.

### 4. *Basic criteria for choosing alternatives*

Three general types of alternatives were discussed to provide the necessary 300 000 kW, using the water and coal resources of the region: possible small and medium-sized hydroelectric plants, and thermal ones. The general criterion adopted for selection may be summarized as follows:

(*a*) Construct first a medium-sized hydroelectric plant, since the absolute increases in demand are less during the first stage, as may be seen from table 41;

(*b*) Towards the end of the period, when the annual increases in demand are greater, construct a large hydroelectric plant;

(*c*) During the intermediate years, construct thermal plants to meet the demand and add flexibility to the system.

### 5. *Discussion of alternatives for the medium-sized plant*

The discussion began with an analysis of the alternatives offered by two power stations (called here I and II), which together could have an installed capacity of 50 000 to 70 000 kW, the maximum base load in winter being some 35 000 kW. Although these plants were interesting, since they would be near the largest consumer centre, the idea was discarded since their construction was linked to the execution of certain water supply works, regarding which no firm decision had yet been reached. In addition, because of the length and situation of the conduit, the construction period would be too great. The analysis then examined possible alternatives III and IV (13 000 and 14 500 kW, respectively, of winter maximum base load). These plants were not considered capable of construction immediately because the base load and winter output were too small; the region already had a deficit and urgently required greater power.

Alternatives V and VI were examined later, but considered to be of little importance. Finally, alternatives VII and VIII were analysed; these were possible plants whose water was made available to a private enterprise under a concession. Alternative VII could be developed to up to 58 000 kW and VIII up to 22 000 kW; VII was preferred and it was included in the programme, because of its greater

[5] In plants without a reservoir, the power depends entirely on the volume of water flowing (see the technical appendix which follows this example).

[6] Explanations of technical terms are given in the technical appendices at the end of case 3 and of this case.

power, although its construction was more difficult. Its winter maximum base load would be 40 000 kW and it would enter into service in 1960.

It will be appreciated that size and urgency were the predominant factors in this case, but no choice would have been possible without previous studies which showed the general characteristics of the alternatives.

### 6. *Decision between large hydroelectric plants*

The following four alternatives of over 120 000 kW were examined for the large plant.[7]

A: Plant with 180 metres head, 130 000 kW.

B: Storage plant, 125 000 kW.

C: Storage plant (different river), 130 000 kW installed.

D: Storage plant (different river), minimum power 165 000 kW.

Alternative D (on the River Rapel) was adopted for the following reasons:

(*a*) Because of the present level of electrical development in the zone to be served, a plant was advisable which could supply both the winter output and the power required regardless of the hydrological conditions of the year for the run-of-the-river plants already existing or projected. This double flexibility could only be achieved with storage or thermal plants. In the case of Chile, taking into account the minimum number of kWh which this plant must supply, the storage alternative is preferable.[8]

In addition to the general preference for the storage alternative, plant A, which is run-of-the river, was discarded for other reasons: it cannot produce more than 290 million kWh in winter (against 400 million with plant D); and it depends greatly upon the future operating conditions of a projected irrigation reservoir in its river, which cannot be sufficiently appreciated until it has been in operation for some years. This eliminates A for the period under consideration.

(*b*) Past studies of alternative C show that the construction of a dam on the bed of this river would be extremely costly and would limit the height of the reservoir. It would also have little advantage as a source of electricity supply, since the rises in the river are very irregular over a period of years, and the capacity of the reservoir would be insufficient to give complete control.

(*c*) Plant B would obtain its water from the damming of a lake for irrigation purposes, which is at present under way, and depends on the completion of that work.[9] The probable power of 125 000 kW is estimated from extrapolated hydrological statistics based on observations over relatively short periods. It is therefore not known precisely how much water will be available in the reservoir for generating electricity in winter. It was considered better to wait until some years after the completion of the reservoir, during which period hydrological observations would provide reliable data on which to base studies of alternative B.

(*d*) Plant B, although it has a reservoir, is a mountain plant. If this were to be built first, the supply to the main consumer centre in the capital of the country would depend on three mountain plants, all in the same area, which would supply more than half the power required and which would be linked to the consumer area by 320 km of transmission lines, including 100 km through mountainous country. This would be most unwise from the point of view of possible interruptions of the supply.

(*e*) Alternative D (the River Rapel) has the following advantages over the others:

[7] The capital letters refer to plants at particular sites.

[8] The "case of Chile" implies abundant water resources in relation to demand; tight coal supplies; acute balance-of-payments difficulties. The fact that hydroelectric plants are preferable to thermal ones does not imply that the latter method should be discarded out of hand.

[9] A water administration agreement was reached.

**Table 42**

CASE 15. POWER AVAILABLE IN CHILE, ZONE A OF THE THIRD GEOGRAPHICAL REGION[a]

*(Thousands of kW)*

| *Year* | *Peak winter demand in zone A* | *Available power* | | *Total* | *Deficit* |
|---|---|---|---|---|---|
| | | *From the private enterprise and industrial plants* | *Surpluses from zone B and other works under construction or planned* | | |
| 1951 | 268.9 | 195.9 | 67.7 | 263.6 | 5.3 |
| 1952 | 291.3 | 195.9 | 65.3 | 261.2 | 30.1 |
| 1953 | 310.8 | 195.9 | 62.9 | 258.8 | 52.0 |
| 1954 | 331.8 | 195.9 | 60.5 | 256.4 | 75.4 |
| 1955 | 354.1 | 195.9 | 150.3 | 346.2 | 7.9 |
| 1956 | 378.0 | 195.9 | 147.3 | 343.3 | 34.8 |
| 1957 | 403.6 | 195.9 | 144.0 | 339.9 | 63.7 |
| 1958 | 431.0 | 195.9 | 149.6 | 345.5 | 85.5 |
| 1959 | 460.3 | 195.5 | 182.9 | 378.8 | 81.5 |
| 1960 | 491.7 | 195.9 | 218.8 | 414.7 | 77.0 |
| 1961 | 525.3 | 195.9 | 214.3 | 410.2 | 115.1 |
| 1962 | 561.2 | 195.9 | 264.5 | 460.4 | 100.8 |
| 1963 | 599.8 | 195.9 | 314.1 | 510.0 | 89.8 |
| 1964 | 641.0 | 195.9 | 363.5 | 559.4 | 81.6 |

[a] Including works under construction in 1952 and the two new hydroelectric plants contemplated for this region in the programme (1953-1964).

## Table 43

CASE 15. AVAILABLE WINTER BASIC LOAD IN CHILE, ZONE A OF THE THIRD GEOGRAPHICAL REGION, FOR THE PERIOD 1953-64

*(Thousands of kW)*

| Year | Peak winter demand | Existing plant | | | New works under construction or planned | | | | | | Type of plant | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cia. Chilena de Electricidad | ENDESA Sauzal Cipreses | Others[a] | 3rd Unit Laguna Verde | Sausalito | Isla | Thermo-electric | Tinoco | Rapel | Thermal | Hydro-electric | Total | Deficit | Reserve |
| 1951 . . . . . | 268.9 | 154.8 | 67.7 | 41.1 | — | — | — | — | — | — | 82.9 | 180.7 | 263.6 | 5.3 | — |
| 1952 . . . . . | 291.3 | 154.8 | 65.3 | 41.1 | — | — | — | — | — | — | 82.9 | 178.3 | 261.2 | 30.1 | — |
| 1953 . . . . . | 310.8 | 154.8 | 62.9 | 41.1 | — | — | — | — | — | — | 82.9 | 175.9 | 258.8 | 52.0 | — |
| 1954 . . . . . | 331.8 | 154.8 | 60.5 | 41.1 | — | — | — | — | — | — | 82.9 | 173.5 | 256.4 | 75.4 | — |
| 1955 . . . . . | 354.1 | 154.8 | 150.3 | 41.1 | — | — | — | — | — | — | 82.9 | 263.3 | 346.2 | 7.9 | — |
| 1956 . . . . . | 378.0 | 154.8 | 147.3 | 41.1 | — | — | — | — | — | — | 82.9 | 260.3 | 343.2 | 34.8 | — |
| 1957 . . . . . | 403.6 | 154.8 | 144.0 | 41.1 | 40 | — | — | — | — | — | 122.9 | 257.0 | 379.9 | 23.7 | — |
| 1958 . . . . . | 431.0 | 154.8 | 140.6 | 41.1 | 40 | 9 | — | — | — | — | 122.9 | 262.6 | 385.5 | 45.5 | — |
| 1959 . . . . . | 460.3 | 154.8 | 136.9 | 41.1 | 40 | 9 | 37 | 40 | — | — | 162.9 | 295.9 | 458.8 | 1.5 | — |
| 1960 . . . . . | 491.7 | 154.8 | 132.8 | 41.1 | 40 | 9 | 37 | 40 | 40 | — | 162.9 | 331.8 | 494.7 | — | 3.0 |
| 1961 . . . . . | 525.3 | 154.8 | 128.3 | 41.1 | 40 | 9 | 37 | 80 | 40 | — | 202.9 | 327.3 | 530.2 | — | 4.9 |
| 1962 . . . . . | 561.2 | 154.8 | 123.5 | 41.1 | 40 | 9 | 37 | 80 | 40 | 55 | 202.9 | 377.5 | 580.4 | — | 19.2 |
| 1963 . . . . . | 599.8 | 154.8 | 118.1 | 41.1 | 40 | 9 | 37 | 80 | 40 | 110 | 202.9 | 427.1 | 630.0 | — | 30.2 |
| 1964 . . . . . | 641.0 | 154.8 | 112.5 | 41.1 | 40 | 9 | 37 | 80 | 40 | 165 | 202.9 | 476.5 | 679.4 | — | 38.4 |

[a] The 4 000 kW which the Carena plant supplies to zone B have been deducted.

(i) The possibility of building a large reservoir, with a dam on solid foundations, which would be low in cost and ensure an ample supply of power.
(ii) Greater capacity. (It has been seen that the size of the anticipated deficit calls for large capacity).
(iii) The transmission lines to the two most important consumer centres would be only about 100 km long, and the power could be transmitted at 154 000 volts.

Alternative D would provide almost complete control of the river, but it has the disadvantage that 27 000 hectares of land would be flooded, of which 8 300 are of first quality. Economic studies were therefore undertaken to find the optimum solution. Until such time as these are completed, a minimum height of 86 metres has been estimated, which would mean flooding only 6 400 hectares, 2 300 of which have no agricultural value (river bed).

The plant would have 165 000 kW installed power and would be capable of generating 600 million kWh per year. It would be installed in three units of 55 000 kW each.

Allowing for power availability from works under construction and from the new hydroelectric plants selected on the basis of the criteria described above, the situation in zone A during the period 1953-1964 will be as shown in table 42.

It can be seen from table 42 that there will be a deficit of 52 000 kW in 1953, and 75 400 kW in 1954. This will fall in 1955 to 7 900 kW, when one of the plants under construction enters into operation. After that year, the deficits will be increasingly greater until, in 1962-1963, the second hydroelectric plant of the programme begins operation. This will reduce, but not eliminate the deficit. Table 42 shows the deficit to be 115 000 kW in 1961 and 81 600 in 1964. To meet this, it would be necessary to build new generating plants to a total capacity of 120 000 kW, so as to allow a minimum reserve percentage.

It was decided that the majority of the plants should be thermal for the following reasons:

(*a*) In an extensive system, such as that in the example, with much of the output being generated by run-of-the-river power stations, it is advisable to maintain an adequate percentage of thermal plants for security and elasticity of supply. In 1952, the available power in zone A was 260 000 kW, of which 32 per cent (81 000 kW) was from thermal plants. If only the present plants were maintained, in 1964 (the final year of the programme) the thermoelectric availability would be 14.5 per cent (the same 81 000 kW, out of a total anticipated supply of 557 000.) It is true that by that time there would be two plants with reservoirs and that it would not be necessary to maintain as high a percentage of thermal plants as in 1952. Nevertheless, the chief storage plant (Rapel) would not be completed until 1960, and until then the thermal plant would be necessary, since it would be inadvisable to reduce the percentage so rapidly.

If the 120 000 kW deficit in zone A is made up with thermal units, the proportion of about 30 per cent would be re-established. If only 80 000 thermal and 40 000 hydraulic units are added, the proportion of thermal plants would be 23.7 per cent.

(*b*) Another reason is urgency. None of the hydroelectric plants studied could be in service before 1957, and any other project would require an even longer period. Meanwhile, the deficit situation is such that the 120 000 kW still lacking must be brought into service very soon, in 1956 if possible. This can only be achieved with a thermoelectric plant.

(*c*) A further reason for the urgency is the complete absence of reserves in the system, which is aggravated by the fact that most of the plants have old machinery, many of them having been in use for nearly 50 years.

This leads to the conclusion that the installation of at least 80 000 kW of thermoelectric power is justified, and it is estimated that this could reasonably be divided between two plants of 40 000 kW each. The remaining 40 000 kW would be required in 1960, and some of the hydroelectric plants mentioned above could be considered for this purpose.[10]

Finally, the forecasts of the demand for power and energy and the dates of entry into operation of the plants have been presented in figures, accompanied by tables showing the demand for power and energy and yearly availabilities according to the timing of the programme.

The entire electrical development programme planned for the region during the period 1953-1964, expressed in terms of winter maximum base load, is presented in table 43.

The study also contains figures which show the development in terms of energy. Finally, there is a figure showing hourly winter peak loads, annual consumption and availabilities.

In order to improve the supply to the third geographical region of the country during the first years of the period, it is proposed to utilize a transmission line which will carry up to 50 000 kW from the fourth geographical region.[11]

## *Technical Appendix on the Engineering of Power Stations*

### 1. *General considerations*

Whatever method may be used to project demand, the first task in the approach to the technical problem of supply is to express demand in terms of the installed capacity required. The difference between required and existing demand will show what new generating capacity has to be installed.

Having decided the amount of power which must be supplied and the capacity to be installed, the next problem is to decide between possible alternatives for the provision of this capacity. For this purpose the characteristics of the system and of each power station have to be defined. This calls for a study of investment and production costs, and an economic evaluation of these alternatives from various angles.

Power stations can be grouped into two general types according to the natural resources they transform into electric power. One type is the hydroelectric power station, which uses the energy provided by the watercourses of the country or region; the second is the thermoelectric plant, which transforms the thermal energy of fuels into electricity.

Therefore, considering the electrical system as a whole, the basic question is whether to use thermal or water resources to generate electricity. Three factors will affect the decision:

(*a*) The natural sources of energy available;

[10] Provisionally, and only for programming purposes, these 40 000 kW were also considered to be of thermal origin.

[11] See comments on interconnexion in the technical appendix.

(*b*) The alternative uses of these resources, including the possible export of fuels;

(*c*) The facilities, limitations and technical combinations possible in the use of these sources of energy to meet the demand in question.

When an over-all energy programme has been completed for a country, a large part of these problems will have been solved. It will then be known what electric production capacity is to be installed, and which part of it will be thermal and which hydraulic. The project-maker's task will be to study specific plants within these points of reference.

### 2. *Hydroelectric power stations*

#### (a) *Hydroelectric power*

The energy utilized in hydroelectric power stations is represented by a combination of two basic factors: the volume of water available (also called the flow or discharge), generally measured in cubic metres per second, and the difference in levels between which this flow can be utilized (head).

The flow depends basically on the hydrological conditions of the area being studied, while the head depends on technical and economic limitations. The geological and climatic factors, in addition to topographical and hydrographical conditions, complete the basic picture of hydroelectric potential from the point of view of natural conditions.

Hydroelectric power stations can generate only according to the availability of water, which usually varies in the course of the day, season, and year, in cycles which depend upon the general hydrographical conditions of the area, hence the concept of "hydrological security", i.e., the likelihood of obtaining a guaranteed flow of water over a certain period of time. The two main types of hydroelectric power station and run-of-the-river storage plants depend on the possibility of controlling this flow by pondage.

The technical study of a hydroelectric plant covers essentially the following aspects:

(i) Research into the water resources and the possibility of using them according to local topographical, geological and meteorological conditions and the nature of the watercourse;

(ii) Decision on the type of plant to be built and planning of the civil engineering works;

(iii) Planning the electrical engineering at the production, transmission and final distribution stages.

The very nature of the water resources, depending as they do on hydrological cycles, necessitates observations over a long period of years.

These three aspects are closely inter-connected, and, in order to arrive at the final solution, all of them will have to be considered in the light of the general programme and of the economic and technical elements of the problem. The electrical engineering of a power station includes the aspects relating to anticipated demand. Civil engineering must deal with the problem of utilizing the energy of the river, according to its natural characteristics, that is, utilizing the potential energy of the flowing water. Joint planning of these two aspects of engineering therefore implies co-ordination of the characteristics of the availability of useable energy and the demand for electricity. This co-ordination is represented physically by the common shaft of the turbine, through which the flow of water passes, and the electric generator, from whose terminals the electricity flows to the consumer.

In conventional language, therefore, in a power station there are a "supply" of energy and a "demand" for electricity. The former is represented by the source of energy employed and the installations for its utilization and transformation; the latter is equivalent to consumption requirements. The supply varies in hydroelectric plants according to the hydrological characteristics of the watercourse. Since the demand is also variable, according to its own characteristics, special synchronization problems arise in hydroelectric plants which do not occur in thermoelectric ones, where the supply of energy, represented by fuel, only depends on its procurement.

#### (b) *Storage basins*

The presence or absence of storage basins in hydroelectric plants constitutes the basic difference between the two types into which they were divided above: run-of-the-river and storage.

Run-of-the-river plants are characteristic of the upper or middle reaches of rivers, where the water is used without any large-scale prior storage (up to one day's control), or at best, with only a balancing tank.

Storage plants consist essentially of a dam or retaining wall for the water, at the most appropriate place, (narrow gorge) which will allow the accumulation of water upstream. The amount of water accumulated will depend partly on topographical conditions and the height of the dam and partly on filtration and evaporation (geological and meteorological conditions); its capacity may also be affected by the accumulation of silt carried down by the waters. Storage allows better distribution of the water, and consequently better utilization for generating electricity.

The storage cycle is the period between two dates when it is completely full; the length of these cycles is very important in defining the capacity of the plant and other characteristics. It may be a few hours, a day, a year or several years, depending on the hydrological conditions and the rate of discharge of water, which again depends on variations of demand. The balancing tank—defined later—is in fact a storage basin with a one-day cycle, which is often built in run-of-the-river plants, but some such plants do not have even this limited pondage. In the latter case, the minimum load which the plant should be designed to carry is that of minimum flow; on the other hand, when there is pondage the minimum load may be greater than the minimum flow of the watercourse, because water can be stored.

#### (c) *Flow control*

The difference between power and energy[12] from the point of view of demand may also be expressed in terms of hydrological availability.

If the flow is controlled—daily, seasonally, or in cycles of several years—the possibility of synchronization between available natural energy and the energy demand, on one hand, and the maximum power available and demanded, on the other, will be greater.

In the case of daily control (balancing tank) the water

[12] See technical appendix at the end of case 3.

may be accumulated during the day to meet the peak demand at certain hours; at the same time, less flow can be used during periods of low demand, so that the difference between the water available and demand can be stored during these hours. In the case of seasonal variation, the possibility of control and synchronization with demand increases, since water can be accumulated not only during the day but during the year from one season to another. Surplus water during periods of low demand can be retained for the months of peak demand.

This explains why, in cases where there is control, the average flow of a river does not represent the maximum power demand which might be expected. During variable periods, depending upon whether the control is daily, annual or longer, greater power can be generated than that represented by the average flow, since, as just seen, the larger volumes of water used are compensated by the surpluses produced during hours or months when the demand requires a flow less than the average.

The above explanations may be summed up thus: given a certain head, the total energy available is proportional to the average flow and the maximum available power, which is maximum flow. Control enables the natural energy available to be distributed in such a manner that during certain periods greater power is produced than that which the average flow would provide, and less power in the remaining periods. Studies of hydrological conditions and control possibilities will show what power is utilizable with a given average flow, and this in turn must be synchronized with the peak demand for electricity. The capacity to be installed will therefore depend on a study of available utilizable energy combined with a study of the demand to be met. Storage plants with high control possibilities are similar in this respect to thermoelectric plants, which can work at full power over periods as desired.

The foregoing is very important in the case of networks where there is inter-connexion of run-of-the-river plants and thermal plants, or high-capacity storage plants. For instance, the run-of-the-river plants may be allowed to take the basic load, that is, the part which is always foreseeable and therefore less than the maximum. Thus the run-of-the-river plants would always work at the highest power which the flow would permit, with high load factor; the storage plants take the rest of the load, with all its variations, since their surplus water is never lost but retained to supply peak demand.

There are many possible dam designs and their height will be largely affected by economic considerations. The greater the height, the greater will be the flooded area and also the storage capacity, i.e., the control possibilities and peak power demands which can be met.

When the flooded areas include farm lands, economic calculations become specially important. The productive possibilities deriving from a greater availability of electricity must then be compared with the drop in farm production.

### (d) *Natural resources*

The natural resources required by a hydroelectric plant depend on hydrological, geological, topographical and meteorological conditions. These factors are decisive in determining the sites and possible size of a plant and the characteristics of the turbine.

*Hydrology.* Hydraulic energy is directly related to the hydrological cycle of the area, and this in turn depends on solar energy. The latter produces the evaporation of small quantities of water from the planet, which, passing to the atmosphere in the form of vapour, then falls to earth as rain, snow, hail or dew. Part of the water which falls drains from the high land towards the sea because of slopes. From the sea, the water evaporates again, completing the cycle. It is possible to make use of that part of the cycle where the water drains and where the other natural conditions allow it to be accumulated and used economically.

Hydrographic basins—that is, areas where water is attracted towards specific watercourses—may depend fundamentally on snow or rain, which will affect the river cycles and the various possibilities of utilizing them so far as hydrological security allows.

In addition to the physical limitations to the utilization of water flows, there are also economic limitations, since the hydrological cycle has a decisive effect on other uses in fields such as irrigation, hygiene, transport and industry. In many cases these limitations necessitate the study of multiple projects to cover the various possibilities of use simultaneously.

It is therefore absolutely indispensable that hydrological studies should be made. They consist basically in flow measurement at various points of the river and of the hydrographic basin in general. Information on rainfall or snowfall is equally necessary. These data, obtained over a period of years, are tabulated, systematized and plotted on graphs for analysis according to certain specially developed techniques. The essential information is the average available flow during a year or a number of years, in varying degrees of probability, since the available energy is directly proportional to the flow and the head. The degree of certainty of each of these flows is called hydrological security and it is a factor of considerable influence in determining the size of the plant.[13]

The following are the functions of the hydrological service:

(i) Installation of limnometers and limnographs, rain gauges and recorders, snow recorders, snow drift indicators, evaporimeters and recorders, gauging stations, weirs, etc.
(ii) Checking instruments and the gauging stations mentioned above.
(iii) Selection and training of observers or instrument readers.
(iv) Reception and systematization of readings.
(v) Preparation of statistics of average daily and monthly flows.
(vi) Preparation of seasonal rating graphs for flows and other data.
(vii) Study and application of different methods of interpolation and extrapolation of flow statistics.
(viii) Special studies.

*Topography.* The formation of the terrain is important in determining the most suitable point for installing the water take-off or reservoir. It will affect the planning of the reservoirs as regards the size and height of the dams. Transport possibilities must also be remembered in the study, especially during the construction period.

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[13] There are two basic concepts of hydrological security: monthly, which refers to the percentage probability of a specific flow during a given month; and that which refers to the probability of a given flow at any time of the year.

*Geology.* This affects several factors: base for foundations; permeability of the soil (filtration losses); possibility of using earth dams, suitability for tunneling, etc.

*Meteorology.* This naturally affects the hydrological cycle (precipitation, flow cycle, evaporation). It is also connected with the construction and operating problems of the power station, which must be considered in the work schedule.

(e) *Civil engineering in hydroelectric power stations*

The fundamental aspects of a hydroelectric plant so far as civil engineering is concerned are as follows:

*Catchment area.* As the name indicates, this covers the works required for the retention of the waters to be used, so as to convey them to the site of the plant.

*Sand and gravel removal.* These works are often necessary to avoid the possibility of sand or gravel entering and damaging the turbines. Their inclusion in the work programme depends on local circumstances.

*Conduits.* These convey the water from the catchment area to the point of drop. They may be canals, flumes, pressure tunnels, etc.; siphons or other civil engineering works are sometimes necessary, all of which must be specified in the project. A problem of technical alternatives with considerable economic implications arises in connexion with the study of conduits. The object is to convey water from some point of the river, by means of conduits—canals, tunnels, etc.—whose gradient is less than that of the natural river-bed, so that differences in height are obtained between the level of the conduits and that of the river into which the water will be discharged after use. It has already been explained that the available energy depends on both the flow and the head of the water. The study on conduits takes this latter factor into account, and the decisions are reached by comparing the cost of the alternative methods with the amount of energy gained or lost with the different heights obtained according to the various alternatives. Other natural conditions play an important part. For instance, in order to obtain a given height, a canal may be very long compared to a possible tunnel, but the cost per metre of tunnel may be much greater and may depend very largely on geological conditions.

*Balancing tank.* When it is desired to control daily the water passing through the turbines and to ensure the volume required for the daily peak load period, balancing tanks are built to provide pondage for possible variations in the flow and demand during the day. Their inclusion or omission will depend on hydrographical and topographical conditions and on the type of plant. They will be unnecessary in the case of storage plants.

*Surge tank.* This also stores water, but on a smaller scale, to regulate the intake into the delivery piping; it is always installed. At times surge columns, which perform the same function, are drilled in the rocks.

*Delivery piping.* These are the pipes through which the water falls into the turbines. They may be of steel, reinforced concrete or concrete, and they lead from the surge tank to the power house. The difference in level between the two ends of the delivery piping provides the head or power drop of the water.

*Power house.* This is the building where the actual generating equipment is installed, the most important being the turbo-generators (combinations of one turbine and one generator). The turbines are normally of one of three types: Pelton or impulse wheel, suitable for large heads; Francis or reaction wheel, for medium heads; and Kaplan or propeller wheel, for low heads.

The generators are coupled direct to the turbine shaft. Their specifications appear under electrical engineering, since they depend on the characteristics of demand. The turbine specifications are a civil engineering matter and depend essentially on local hydrological and natural conditions in general, which determine the possibilities of reservoirs, heads, etc.

*Tail race.* This is the discharge of water from the turbines after use.

*Other works.* The specific conditions of any plant may require further works, which will vary in each case.

(f) *Electrical engineering of projects*

A distinction should be made between the aspects mentioned below, which will normally be the same for both thermal and hydraulic plants.

I. Production, divided into:

*Generating.* This is the installation of the generator, whose characteristics will depend on demand.

*Switchboards.* Control and instrument panels.

*Switchgear.* Includes costly elements, since it must be capable of breaking on-load circuits carrying considerable energy.

*Protection.* Lightning conductors, etc.

*Auxiliary services.* Batteries, pumps, local lighting, etc., for the power station.

*Transformers* for raising the voltage generated to that which will be carried over the transmission lines.

II. Transmission, consisting of the following:

*Pylons,* to carry the cables.

*Conductors and insulators.*

*Substations.* Transformers, switchgear and controls.

*Voltage regulation* and power factor correction equipment (condensers, transformers, boosters, etc.).

III. Distribution:

*Substations*

*Distribution grids.*

### 3. *Thermoelectric plants*

In these plants, thermal energy is obtained from various fuels. Until recently there were two general types: those where the motive power was a steam engine (generally turbine) and those with an internal combustion engine (diesel or other).

Progress in the utilization of atomic energy now heralds another type using nuclear fuel. A technical revolution is in progress, the outcome of which cannot be predicted and whose characteristics cannot yet be described, even broadly, in this *Manual.* The following explanations refer only to the two conventional types of thermoelectric plants.

From the point of view of generating electric power for public service networks, steam power stations are the most important. Diesel plants are used only in special cases and generally supply specific services, such as isolated mines or small townships distant from the more important networks, where transport is a fundamental problem and where hydroelectric possibilities do not exist. Freight is also an important item in thermoelectric plants.

The technical elements of the study—the installation and operation of a thermoelectric plant—are usually less complicated than for a hydroelectric plant. On the other hand, the equipment of a thermal plant is more complex.

Individual consideration of a thermal plant does not require a careful study of the hydrological, geographical and topographical features mentioned earlier.[14] It may be installed more quickly, which is an advantage in urgent cases.

The total cost of investment, transmission and distribution per kW installed, is usually lower for thermal than for hydraulic plants, although favourable local conditions may reverse this. The foreign exchange component of the investment per kW is often higher for thermoelectric plants since the equipment is more complex. This point will be dealt with in more detail when investment is discussed.

A fundamental economic and technical problem in this type of plant is efficiency in the use of fuels, which is measured in terms of calories per kilowatt-hour generated. The equivalent amount of coal per kWh varies in relation to this efficiency and the quality of the fuel.[15] The efficiency of each project must be estimated on the basis of sound background data; in general efficiency will be higher with better quality equipment, which means a higher level of investment. The fixed expenses of depreciation increase in direct proportion to the initial costs of the equipment and tend to reduce the advantages of higher efficiency. This also depends to a great degree on the relationship between the annual production of energy (kWh per year) and the total rated capacity, i.e., the plant factor.

From this aspect local conditions determine the optimum points, which should also be considered in the light of their effects on the balance of payments. Spares and maintenance costs will generally be in foreign currency, while those of fuel may be in either national or foreign currency depending on local conditions. This type of analysis will therefore affect the technical specification of the equipment.

### 4. *Interconnexions*

The economic and technical conditions which determine the availability of energy in each case raise the problem mentioned earlier of seeking optimum combinations in the utilization of fuel sources to meet a given demand. The most common solution to such problems often consists in integrating thermal and hydraulic plants in systems which may be predominantly either thermal or hydraulic. In other words, there will be optimum combinations as regards the utilization of either type and there will also be optimum utilization as regards the combined use of both types. Flexibility in the use and control of electric power and the possibilities of interconnecting plants open a wide field for technico-economic analysis.

The desired solution is one where the base load is carried by a high-efficiency plant, which operates with a high load factor, while the additional power to meet peak loads is supplied by other plants which operate only part of the time. In general, the newer or more efficient installations carry the base load, since they work continuously; less efficient plants, or those with high operating costs, are usually left to carry the peak loads. It may thus be advisable to project a run-of-the-river installation with a high load factor, even though maximum utilization of the flow is sacrificed, leaving the peak loads to be carried by low-efficiency thermal plants. Conversely, it may be preferable to plan the project so that new thermoelectric plants carry the base load, leaving the peaks to the hydroelectric plants if hydrological conditions and demand characteristics make this desirable.

It is therefore advisable to consider power station projects not as individual plants but rather in relation to the possibilities of interconnexion with an electrical production, transmission and distribution grid or network. Except in special isolated cases—such as some mines—the normal procedure will be to examine the electrical situation of a region or a country as a whole and to project individual plants in a way which will lead to the greatest efficiency in the operation of the system.

The advantages of interconnexion are clearly seen when considering the installation of new plants in an area where there are old, small and inefficient plants, which often occurs in under-developed countries. Similar plants may have been installed by industries in order to supply their power needs from their own resources during the early stages of industrialization, but it must be pointed out that a number of small plants is always less efficient than one plant with equivalent power. When large power stations are installed, the older plants can often be utilized by connecting them to the common grid and using them only to meet the peak loads. In this case, the new installations would carry the base demand.

It must also be remembered that it is often possible to make use of electric power generated by using the hot gases or steam produced by many industrial processes. Much of this power is used for the operation of the same industry, but there may be surpluses which could be utilized by connexion to the general network.

To sum up, the technical possibilities of interconnexion will require sector programmes to be drawn up to satisfy electrical demand, if maximum utilization of each plant is to be achieved.

Finally, the possibilities of interconnexion are not limited by national frontiers and may be international in scope. These possibilities have been borne out by experience in Europe but have not yet been tried out in Latin America.

## *Case 16*

### FACTORS WHICH MUST BE CONSIDERED IN A FINAL PROJECT FOR THE INSTALLATION OF MECHANICAL INDUSTRIES

The plan outlined below might serve as a methodological and checking guide to the principal factors which must be taken into consideration for the construction of a new project. The list refers only to the buildings and installations for providing the basic production services, but not the production machinery and equipment, which will naturally vary with the type of industry. The plan is thus very elastic and may be applied to any project.

Not all of the items in the plan will be considered, and further notes may always be added, without going into excessive detail, in specific cases. A list of the main elements and sub-divisions is given below, sub-divided,

[14] In cases of interconnexion, hydrological cycles will also affect a thermal project.

[15] Technical improvements in the design of boilers and the utilization of steam for generating electricity have led to a considerable improvement in efficiency. In the United States, fuel consumption per kWh (in kg of coal equivalent) decreased from 0.626 in 1939 to 0.562 in 1949 and 0.453 in 1954. These figures show that, in the period 1949-1954, efficiency increased more than during the previous ten years. Larger units have also influenced efficiency, and so has the use of higher steam temperatures and pressures. These latter, however, appear to have reached a stage of decreasing efficiency. Finally, the quality of the fuel used will also affect efficiency.

but the very minute details of the original plan are omitted.

The plan is as follows:

1. *Description of the site*

(*a*) Situation (state, city, borough, adjacent streets, etc.).

(*b*) Area.

(*c*) Photographs (adjacent buildings and roads, etc.).

2. *Topographical features of the site*

3. *Examination of the site*

(*a*) Ground conditions (resistance, type of soil, level of underground water, etc.). Tests made.

(*b*) Ownership (deeds and legal history).

(*c*) Data on adjacent buildings (photographs and plans, ground tests, cracks in the walls, etc.).

4. *Approaches*

(*a*) Roads (width, types, authorities responsible for maintenance, distance and connexion with main roads).

(*b*) Paving (width, curves, pavements).

5. *Rail and bus services*

Situation in relation to the site, number of tracks, gauge, switches or sidings, crossings, curves. Passenger bus service.

6. *Public services*

(*a*) *Water.* Authority responsible for the service, situation, size and pressure of mains; rates; wells, levels of underground water, average temperature and average hourly available flow; quality and chemical analysis.

(*b*) *Sewage.* Competent authorities and cost of service; situation and size of the drains and piping, sewage plant.

(*c*) *Gas.* Similar to water and sewage.

(*d*) *Electric power.* Name of the supplier; type of cabling (underground or overhead); characteristics of supply (voltage, phases, frequency, available capacity; whether a sub-station is required or not; rates; cost of meter installation; stand-by systems).

(*e*) *Telephones.*

(*f*) *Telegraphs.*

(*g*) *Other services.* Fire alarms, police, etc.

7. *Government regulations*

(*a*) *Laws and ordinances.* Relating to: buildings, sanitary installations, fire protection, electrical installations, boilers and lifts, industrial areas.

(*b*) *Regulations.* Relating to the following (where there are no laws or ordinances): admissible loads and tensions in buildings from the point of view of stability, height of buildings, ventilation, etc.

(*c*) *Permits.* Requirements and costs; legal questions.

8. *General design of the building and steam installations*[16]

(*a*) *Use of the building.* General purposes; space for manufacture, offices, stores, canteen, male and female toilet facilities; garage, vehicle park for employees and visitors, number of occupants.

(*b*) *Size and proportions.* Layout, height, number of stories, roofing.

(*c*) *Architecture.* (Miscellaneous specifications.)

(*d*) *Structure.* (Type of materials used.)

(*e*) *Loads.* Live, dead, movable, multiple, foundations.

(*f*) and (*g*) *Foundations and superstructure.* (Specifications of foundations, walls, roofs, windows and doors, stairs, interior finish, painting and decoration.)

(*h*) *Special installations and other building elements.* Special installations (fire and burglary protection, mezzanines, wire fences, first aid room, closets, etc.).

(*i*) *Equipment for the provision of services. General sanitary installations:* general and kitchen hot water supply; wash-rooms, canteens, hospital and first aid stations, common sanitary services, ventilation, heating and air-conditioning. *Industrial piping and tubing:* steam, air, industrial gas, oxygen, acetylene, ammonia, sanitary and industrial water, etc.; meters, gauges, valves. *Electrical installations,* industrial and lighting equipment within the building. *Lifts:* number, size, capacity, speed, etc. *Miscellaneous installations:* kitchen and canteen, laundry, dressing room, incinerator, etc.

(*j*) *Steam generation:* boilers, reheaters, etc. (number, type, make, capacity in kilogrammes of steam per hour, pressure). *Furnace:* volume, combustion rate, temperature, heat losses, heat recovery, economizers, preheaters. *Fuel:* type, source, cost, analysis, calorific power, estimated consumption, transport by rail, lorry or water. *Fuel handling equipment:* unloading, storage, distribution, boiler feeding, ash extraction, pulverizers, etc. *Condensation water:* source, maximum temperature, chemical analysis (will the condenser tubes need to be made of special metal?), cooling (chutes or other system, capacity of the system, source and analysis of replacement water). *Draught:* hearth volume of each boiler, combustion control, smoke stacks (height, interior meter, material, boilers connected to each smoke stack), forced-draught fans (situation, motive power, capacity). *Boiler water:* heating, chemical treatment, replacement water (percentage consumed, source, analysis), return of condensed water.

(*k*) *Site.* Levelling, paving, fencing, etc.

(*l*) *High-level water tank.*

9. *Production*

(*a*) *Installations required for production equipment.* Foundations, anchor bolts, foundation trenches, platforms, collection of waste materials, handling of turnings, scrap and cooling liquids, special sections (plating shop, heat treatment, inspection, etc.). Requirements for compressed air and heating in the manufacturing process (oil, gas, steam). Oxygen and acetylene storage. Drainage, ventilation and electrical connexions (alternating and direct current, connected loads for each section). Conveyors for handling materials. Access for service and maintenance.

(*b*) *Handling of foundry sand.* Storage capacity, methods of extracting washing water; unloading; transport system, etc.

### *Case 17*

### Subjects covered in a technical report on the rehabilitation of a railway

This case illustrates the type of material included in a report on the rehabilitation of a railway and shows the form, order of presentation and coverage given to each subject in the report. Although this pattern will vary

[16] This section is a check-list of the common essential factors in the development of the original design for a variety of projects.

according to the case, it may be useful and offer some suggestions regarding projects for the improvement of railways in operation.

In addition to engineering problems proper, the study also includes a traffic projection and a financial analysis of the enterprise. Further detail concerning these two aspects are given separately.[17] Only a general outline of what is covered in the study and some explanation of the technical aspects of the programme will be given here.

### A. LAYOUT OF THE REPORT

The study is divided into 12 chapters and contains 22 tables.[18] The subjects covered and the scope of each chapter may be seen from the following:

1. *Index of the report on the Ferrocarril del Pacifico (México)*. Introduction (letter to the Chairman of the Railway Board) (2 pages).

I. *The Company and its properties*

A. The history of the Company (3 pages);
B. Geographical situation: climate, population, products of the region, other railways and connexions, other transport agencies (6 pages);
C. Description of the property: main line, branch lines, ballast, sleepers, rails, general comments on the permanent way, bridges and tunnels, drainage, rights of way, buildings, communications, workshops, machine shops, equipment (17 pages);
D. Traffic (3 pages);
E. Employees (2 pages);
F. Profits in past years (5 pages).

II. *Traffic problems and prospects: freight*

A. Recent changes and trends (3 pages);
B. Government projects in the region (2 pages);
C. Influence of other means of transport: road, sea, other railways (2 pages);
D. Cost problems (2 pages);
E. Estimate of future income: including an analysis of the market for railway services in the region.

III. *Traffic problems and prospects: passengers*

An analysis is made of the impact of the following factors on future passenger traffic: competition from other means of transport, changes in fares, prospects of future income from passengers, express service (parcels), postal service and other income. Finally a projection is made (60 pages).

IV. *Maintenance of the permanent way and structures*

Analysis of expenditure (16 pages).

V. *Maintenance of equipment*

A. Locomotives (5 pages);
B. Freight wagons (3 pages);
C. Passenger coaches (3 pages);
D. Depreciation (2 pages).

VI. *Transport*

Recent changes and trends. Analysis of the operation of passenger and freight trains, marshalling yard and station operation, other transport, supervision, accidents, telegraph, telephone, and train despatching systems (13 pages).

VII. *Traffic and miscellaneous items (3 pages)*

VIII. *Renting of equipment, common installations, taxes and other balance sheet items*

The expenses of renting wagons or other equipment to or from other enterprises are analysed here, together with the receipts and expenditure relating to the use of common installations. There is also an explanation of certain items in the final accounts of receipts and expenditure (17 pages).

IX. *Organization, administration and labour problems*

This section covers staff administration and trade union problems (19 pages).

X. *The rehabilitation problem, and its estimated cost*

A. Permanent way and works. Includes a general examination of rehabilitation requirements and of bridges, tunnels and station buildings (3 pages).
B. Estimate of the rehabilitation requirements of the permanent way. Includes general questions, cleaning of track and approaches, levelling and excavation of ditches, ballast, sleepers, rails and other line material, rehabilitation of bridges, culverts, section houses, boarding-coaches, communication systems, track machinery, estimated cost of track rehabilitation programme (10 pages).
C. *Equipment*
   (i) Diesel locomotives and servicing installations: investment programme for the forthcoming years, analysis of savings derived from dieselization and facilities recommended for maintenance and handling of diesel locomotives (8 pages);
   (ii) Freight wagons and their servicing equipment. An analysis is made of wagon requirements, including: closed wagons belonging to the Company, interchange of traffic with United States and Mexican railways, local traffic, total demand for wagons, and repair facilities for freight wagons (5 pages);
   (iii) Priority in expenditure. An analysis is made of the sequence of the proposed investments.

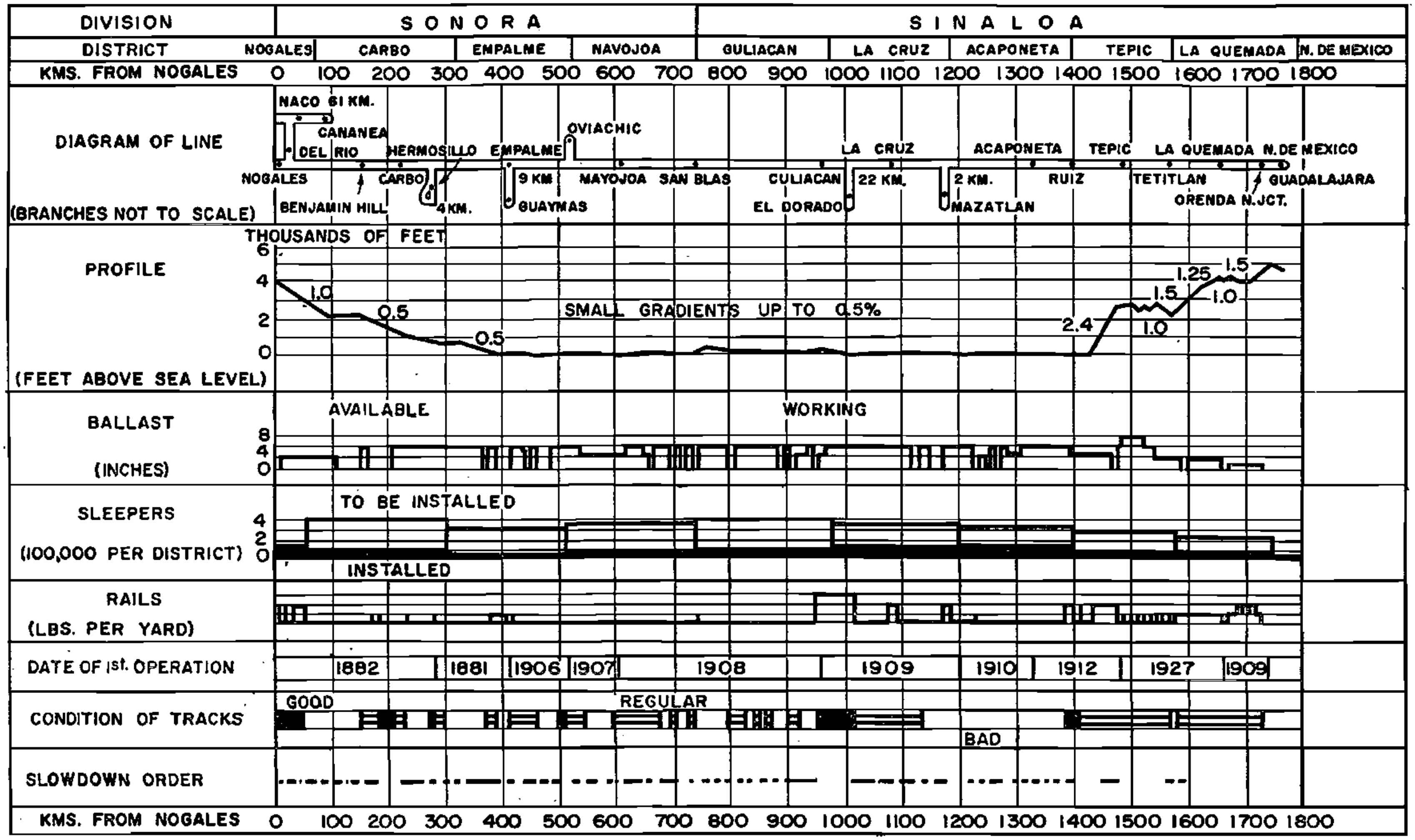
XI. *Forecast of income, expenditure and balance*

A. Expenditure on maintaining the permanent way (2 pages);
B. Equipment maintenance expenses: all types of repairs, depreciation and withdrawals from

[17] See chapter II, case 2, and chapter VII, case 2, respectively.
[18] Prepared by Coverdale and Colpitts, engineers, New York.

Figure 2

CASE 17. CONDENSED DATA OF PROFILE AND TRACK, *FERROCARRIL DEL PACIFICO*, MEXICO



service, improvements and other expenses (3 pages);

C. Transport expenditure: freight and passenger trains, marshalling yards, stations, supervision, accidents, telegraphs, telephones, train despatching and other transport expenses (4 pages);

D. Other operating expenses (1 page);

E. Renting of equipment. Net payments (2 pages);

F. Taxes on railway operation, which are added to the income of the enterprise (1 page);

G. Income other than from railway operation (1 page);

H. Net income before the deduction of overhead expenses (2 pages);

I. Cash balances by sources, annually (3 pages).

XII. *Summary and conclusions*

2. *Tables*

1. Operating balance, 1948-1952 (income and expenditure);
2. Statistics of freight receipts (1936-1952);
3. Statistics of freight receipts, by types;
4. Sheet 1: Irrigation systems used within the area served by the *Ferrocarril del Pacífico;*
   Sheet 2: Future irrigation programme within the area served by the *Ferrocarril del Pacífico;*
5. Annual *per capita* electrical consumption (1950-1952);
6. Tracks classified according to their type and construction (1943-1956);
7. Estimated statistics by type of freight (1954-1963);
8. Complete wagon loads of perishable goods which originate in the *Ferrocarril del Pacífico* area and are exported via Nogales;
9. Comparison of the movement of manufactured goods and population growth;
10. Statistics of passenger traffic receipts;
11. Estimated income and expenditure budget;
12. Receipts from parcels, etc.;
13. Sheet 1: Track maintenance expenses (1948-1952);
    Sheet 2: Equipment maintenance expenses (1948-1952);
    Sheet 3: Traffic expenses (1948-1952);
    Sheet 4: Transport expenses (1948-1952);
    Sheet 5: Miscellaneous expenses (1948-1952);
    Sheet 6: General expenses (1948-1952);
14. Operating expenses and percentages, general accounts (1938-1952);
15. Operating statistics for passenger and freight trains (1948-1952);
16. Late arrivals of passenger and freight trains;
17. Comparison of traffic trends and number of employees (1928-1956);
18. Estimated cost in dollars and Mexican pesos of the rehabilitation programme;
19. Estimated operating and maintenance expenses of diesel and steam locomotives;
20. Estimated number of passenger coaches (1953-1963);
21. Statement of cash requirements and sources (1954-1963);
22. Statement of additions to and reductions of outstanding debt.

## B. THE REHABILITATION PROGRAMME

### 1. *Main points in the programme*

The technical study revealed that operation of the railway in its current state would be inefficient and uneconomic. There was no possibility whatsoever of meeting an increased demand for service. However, by renewing physical equipment and improving the management, adequate service could be provided and profitable operation would be possible.

Figure 2 provides a diagram of the railway. It shows the points connected by the line, branch lines, gradients, depth of ballast, type of rails, stretches which must be crossed slowly, state of the sleepers, etc. It may be seen, for example, that 46 per cent of the route was in bad condition, 45 per cent in average and less than 10 per cent in good condition. Most of the rails were too light (65 pounds per yard) and worn, the rail anchors were in bad condition and without spikes. Many sleepers were broken, and although the ballast was of good quality, the layer was too thin over most of the track. The timber of the bridges required renewing. Forty per cent of the accidents were due to the poor condition of the track, which had reached the stage where further repair was uneconomic. It would therefore have to be rebuilt, with adequate ballast, good sleepers and heavier rails.

New equipment would have to be purchased, and further investment would be necessary in wagons, buildings and the improvement of communications.

To sum up, the rehabilitation programme included the following: complete change of the track, with the following improvements: replacement of steam by diesel-electric locomotives; construction of maintenance shops for the diesel locomotives; repair of existing wagons and purchase of new ones; renewal of the communication system, and improvements in operation and management.

### 2. *Rehabilitation of the permanent way*

The changing and improvement of the permanent way included:

(*a*) *Clearing 620 kilometres of right of way* (10 metres on one side of the main line and 15 on the other, with the greater distance on the side of the posts).

(*b*) *Weeding of 1 000 kilometres.*

(*c*) *Levelling and ditch-digging.*

(*d*) *Ballast.* The average depth of ballast under the sleepers varies at present from 0 to 6 inches, whereas there should be a minimum of 8 inches to withstand prospective traffic. Almost 1 360 000 cubic metres of crushed stone would be required; 120 wagons are in service to transport it, which would be sufficient under the proposed programme. During each of the first two years, 668 kilometres will be completed, 591 in the third, and 153 in the fourth. This makes a total of 2 080 kilometres, which includes the duplication required in a four year programme. No difficulties are expected as regards the quantity or quality of the ballast, since there are quarries along the length of the line.

(*e*) *Sleepers.* The present spacing of 1 790 per kilometre is considered adequate, although over one stretch where the rails were changed, it was increased to 2 020 per kilometre. The average in 14 United States railways, with the same traffic density as the *Pacífico,* is 1 840 per kilometre, that is, only 3 per cent more.

The size used is 7 by 8 inches by 8 feet, but it is suggested that this should be changed to 6 by 8 inches by 8 feet, since 6 inches will be thick enough, and a considerable saving would be achieved by using lighter sleepers. The main line has 3 million sleepers, and towards the end of 1953, 773 200 new ones should have been laid. The replacement programme for the remainder would cover four years, with 700 000 in the first year, 630 000 in the second, 540 000 in the third and 356 800 in the fourth. The Company has a project for making its own sleepers in the Sonora mountains, and has bought a creosoting plant. If this programme is carried out, there will be considerable saving, since creosoted material should last twice as long as that used previously.

(*f*) *Rails and other track material.* Some 90 per cent of the 1 728 kilometres of track is laid with rails of 65 to 75 pounds per yard, which is insufficient for either present or future traffic. Most of these rails were laid 45 years ago. The consultants estimated that, although 112-pound rails had recently been laid along some parts of the route, 90-pound rails would be sufficient for the new diesel locomotives and for the freight density projected for the probable useful life of the rails. Nevertheless, the 100-pound rail is normal for light-traffic railways, since 90-pound rails are only made specially to order. The difference in cost between 112- and 100-pound rails would be 2 million dollars.[19]

(*g*) *Rehabilitation of bridges.* The type of bridge repairs required is described.

(*h*) *Other items.* Mention is made of the need for more concrete culverts, 446 section houses for the permanent way repair gangs and their families, 223 boarding-coaches for the auxiliary gangs, repair and modernization of the communication system (telephone posts and transmitters, in respect of which the Government would bear one-third of the cost). Finally there is an item on track machinery (portable mechanical equipment, jacks, spike extractors, track aligners, more rail cars, small cranes and a second-hand locomotive crane).

### 3. *Traction equipment*

The railway owned 131 steam locomotives, with an average age of 43 years, of which more than 25 per cent were out of service for repairs.

The age of the equipment has been one of the main reasons for the unsatisfactory operation of the railway. As a result of the studies it was recommended that the steam locomotives should be replaced by diesel-electric locomotives. The first order was placed for 1 600 HP locomotives weighing 50 000 pounds, or 22 680 kilogrammes per axle, and with a tractive force of 35 700 kilogrammes or 78 750 pounds. This type, used alone, will draw trains slightly heavier than the biggest at present hauled by the steam locomotives. The use of a locomotive with a greater axle weight would not have been advisable without the renewal of most, or all, of the light rails. This would have delayed the installation several years, and in the meantime the old steam locomotives would have deteriorated rapidly in spite of expenditure on their maintenance. The use of the recommended unit would enable dieselization to be begun simultaneously with track repair, thus improving the service immediately. The report also considered the types of shunting or yard locomotives, and those needed for local freight and work trains. The choice for all these services was confined to two types, for obvious reasons of simplification: the 1 600 HP type mentioned earlier and the 800 HP type for lighter work.

As a result of the technical analysis of the traction equipment, it was decided that the complete dieselization of the railway would require a fleet of 33 locomotives of 1 600 HP, and 31 of 800 HP to meet service requirements up to and including 1963.

Since the work schedule for the replacement of traction equipment would be extended until 1958, an expenditure budget was prepared for each year listing steam and diesel locomotives separately, as can be seen in table 44.[20]

### 4. *Repair shop*

The report discusses the situation of the diesel repair shop and stresses the need for good locomotive repair and service facilities. The saving obtained from dieselization in fact derives from more intensive use of the equipment. If, therefore, the equipment is not used at the proper intensity, the heavy initial investment becomes less justifiable. This is the reason why a well-equipped repair shop and a good stock of spares are essential.

### 5. *Wagons*

The programme provides for the complete repair of some 800 closed wagons with at least 30 years' service, and the purchase of further units, within the next 3 or 4 years. The programme should make it possible to repair some 20 freight wagons monthly. The 800 repaired wagons should have a further useful life of 8 years, which would mean that the purchase of a large number of new wagons could be postponed until the rehabilitation programme is completed. In any case, about 300 new wagons will have to be purchased in the coming years, before 1960.

### 6. *Communications*

The improvement of the communications system would cost some 700 000 dollars.

### 7. *Other points in the programme*

The success of the programme depends upon the following improvements in administrative efficiency:

(*a*) Radical changes in accounting systems and in the compilation and analysis of statistics so that the administration can be sure of receiving timely financial and operational reports.

(*b*) Good supervision at all levels and in all departments. It is recommended that training centres should be established for this purpose and that engineers should at the same time be sent abroad for advanced training.

(*c*) Introduction of intensive training facilities for skilled workers, especially for the permanent way and specialized manual work.

(*d*) Establishment of a system for proper inspection of materials and equipment purchased.

(*e*) Installation, if possible, of a plant for the treatment of sleepers, since this could reduce the foreign exchange investment.

[19] Some other reasons are given to justify the choice of weight of the rails and of other track materials, such as fishplates, etc.

[20] The figures are given only as an illustration of methods, since changes occurred after the preparation of the first programme as a result of the devaluation of the Mexican peso and other factors.

**Table 44**

CASE 17. OPERATING COSTS OF RAILWAY TRACTION EQUIPMENT

| | *1954* | *1955* | *1956* | *1957* | *1958* |
|---|---|---|---|---|---|
| Steam locomotive-kilometres | 2 609 048 | 1 098 609 | 498 642 | 277 646 | — |
| Diesel locomotive-kilometres | 2 021 835 | 3 672 904 | 4 447 521 | 4 943 288 | 5 443 008 |
| Total locomotive-kilometres | 4 630 883 | 4 771 513 | 4 946 163 | 5 170 934 | 5 443 008 |
| Number of diesel locomotives in serv. | 100 | 80 | 55 | 27 | — |
| Number of diesel locomotives in serv. | 10 | 22 | 37 | 51 | 64 |
| Average kilometres per steam locom. | 26 090 | 13 733 | 9 066 | 8 431 | — |
| Average kilometres per diesel locom. | 202 184 | 166 590 | 120 203 | 96 927 | 85 047 |
| *Operating costs of steam locomotives (thousands of pesos)* | | | | | |
| Locomotive repairs | 9 500 | 4 058 | 1 868 | 865 | — |
| Amortization | 1 173 | 1 173 | 1 173 | 1 173 | 1 173 |
| Application of deferred charges, repair costs for 1952 | 2 652 | 2 652 | 630 | — | — |
| Round house expenses | 3 823 | 3 462 | 1 362 | 719 | — |
| Lubricants | 316 | 133 | 60 | 28 | — |
| Water | 908 | 382 | 174 | 79 | — |
| Fuel | 9 001 | 3 790 | 1 720 | 786 | — |
| Others | 195 | 82 | 37 | 17 | — |
| Total | 27 568 | 15 732 | 7 024 | 3 667 | 1 173 |
| *Operating costs of diesel locomotives (thousands of pesos)* | | | | | |
| Locomotive repairs | 1 351 | 3 223 | 4 500 | 5 264 | 5 881 |
| Depreciation (4%) | 679 | 1 490 | 2 228 | 2 900 | 3 597 |
| Maintenance of auxiliary equipment | 150 | 162 | 174 | 186 | 199 |
| Round house | 443 | 804 | 974 | 1 083 | 1 187 |
| Lubricants | 244 | 444 | 538 | 596 | 656 |
| Water | 34 | 63 | 75 | 84 | 92 |
| Fuel | 1 476 | 2 681 | 3 076 | 3 293 | 3 561 |
| Others | 152 | 276 | 334 | 371 | 407 |
| Total | 4 529 | 9 143 | 11 899 | 13 777 | 15 580 |
| Grand total (steam and diesel) (in thousands of pesos) | 32 097 | 24 875 | 18 923 | 17 444 | 16 753 |
| Cost per locomotive-kilometre steam and diesel, (pesos) | 6.93 | 5.21 | 3.83 | 3.37 | 3.08 |
| Saving per locomotive-kilometre compared to complete steam operation | 1.54 | 3.26 | 4.64 | 5.10 | 5.39 |
| Total annual saving (thousands of pesos) | 7 132 | 15 540 | 22 949 | 26 372 | 29 338 |
| Total annual saving (thousands of dollars) | 825 | 1 798 | 2 653 | 3 049 | 3 391 |

### 8. *Investment*

At the time when the programme was discussed and approved by the International Bank for Reconstruction and Development, the following amounts had already been allotted for the execution of the programme:

| | *Thousands of dollars* |
|---|---|
| Permanent way and manual works | 3 457 |
| Diesel locomotives | 2 152 |
| Freight wagons | 3 725 |
| Consultants' fees | 67 |
| Miscellaneous | 643 |
| Total | 10 044 |

The estimated investments for 1954-1958 may be seen from table 45, which gives the investment schedule in Mexican pesos and dollars.

## *Case 18*

## Analysis of raw material supply in a paper industry

This is an existing paper industry, which prepared a project for expanding its operations and substituting domestically-produced fibre for fibre imports.

### 1. *Outline of the analysis*

The following is an outline of the analysis of the supply of the various input materials:

(a) *Fibres*

(i) Determination of present unit input of domestic and imported fibrous raw materials required to produce 1 ton of newsprint and 1 ton of other papers (table 46).

Table 45

CASE 17. ESTIMATED COST AND INVESTMENT SCHEDULE, *FERROCARRIL DEL PACIFICO*, MEXICO, 1954-58

| | *1954* | | *1955* | | *1956* | | *1957* | | *1958* | | *Total* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Dollars* | *Pesos* | *Dollars* | *Pesos* | *Dollars* | *Pesos* | *Dollars* | *Pesos* | *Dollars* | *Pesos* | *Dollars* | *Pesos* |
| *Track* | | | | | | | | | | | | |
| Track cleaning | — | 500 | — | 1 000 | | 1 000 | — | — | | | | 2 500 |
| Levelling and ditches | — | 2 000 | — | 4 000 | | 4 000 | — | — | | | | 10 000 |
| Ballast / Sleepers | — | 5 500 | 2 900 | 10 500 | 3 150 | 12 000 | 3 150 | 10 500 | 1 750 | 4 000 | 10 950 | 42 500 |
| Rails and accessories | 1 000 | 200 | 8 000 | 2 000 | 8 000 | 2 000 | 8 000 | 2 000 | | | 25 000 | 6 200 |
| Bridge material | 200 | 500 | 400 | 1 000 | — | — | — | — | | | 600 | 1 500 |
| Painting of bridges | | 500 | — | 1 000 | — | 1 000 | | | | | | 2 500 |
| Section houses | — | 1 000 | — | 4 000 | — | 4 000 | | 2 000 | | | | 11 000 |
| Boarding-coaches | — | 500 | — | 2 000 | — | 1 500 | | | | | | 4 000 |
| Sewage | 25 | 125 | 50 | 250 | 50 | 250 | 25 | 125 | | | 150 | 750 |
| Communications | 700 | 1 500 | — | — | | | | | | | 700 | 1 500 |
| Permanent way equipment | 200 | — | — | — | | | | | | | 200 | — |
| Total, permanent way | 2 125 | 12 325 | 11 350 | 25 750 | 11 200 | 25 750 | 11 175 | 14 625 | 1 750 | 4 000 | 37 600 | 82 450 |
| *Operation equipment and other installations* | | | | | | | | | | | | |
| Diesel locomotives | 1 521 | | 2 042 | | 1 851 | | 1 429 | | | | 6 843 | |
| Spares and tools | | | 180 | | 180 | | 160 | | | | 520 | |
| Other installations | 50 | | 15 | 500 | 20 | 750 | 20 | 750 | — | — | 105 | 2 000 |
| Total, diesel | 1 571 | | 2 237 | 500 | 2 051 | 750 | 1 609 | 750 | — | — | 7 468 | 2 000 |
| Freight waggons | 20 | | 20 | 270 | 20 | 270 | 20 | 270 | — | — | 80 | 810 |
| Total, equipment and installations | 1 591 | | 2 257 | 770 | 2 071 | 1 020 | 1 629 | 1 020 | — | — | 7 548 | 2 810 |
| Total | 3 716 | 12 325 | 13 607 | 26 520 | 13 271 | 26 670 | 12 804 | 15 645 | 1 750 | 4 000 | 45 148 | 85 260 |
| Other costs, in dollars | 100 | — | 150 | — | 150 | — | 100 | — | 100 | — | 600 | — |
| *Consultants' fees* | | | | | | | | | | | | |
| Contingencies (10 dollars, 15% in pesos) | 372 | 1 848 | 1 361 | 3 978 | 1 327 | 4 016 | 1 280 | 2 347 | 175 | 600 | 4 515 | 12 789 |
| Grand total | 4 188 | 14 173 | 15 118 | 30 498 | 14 748 | 30 786 | 14 184 | 17 992 | 2 025 | 4 600 | 50 263 | 98 049 |
| Grand total, in pesos | 66 523 | | 219 472 | | 215 136 | | 195 292 | | 29 913 | | 726 336 | |

### Table 46

CASE 18. UNIT CONSUMPTION OF FIBROUS MATERIALS

*(Kilogrammes)*

| | |
|---|---|
| A. *To produce 1 ton of newsprint* | |
| Mechanical pulp | 905 |
| Unbleached sulphite pulp (imported) | 118 |
| Waste paper | 77 |
| Total | 1 100 |
| B. *To produce 1 ton of other papers* | |
| Bleached wood pulp (imported) | 153 |
| Bleached straw pulp (domestic) | 192 |
| | 345 |
| Unbleached pulp: | |
| Imported sulphite | 175 |
| Imported Draft | 207 |
| | 382 |
| Other fibres: | |
| Mechanical pulp | 240 |
| Waste | 193 |
| Total | 1 160 |

### Table 47

CASE 18. FIBROUS MATERIAL REQUIREMENTS[a]

*(Tons)*

| | *1955* | *1960* |
|---|---|---|
| *Projected production* | | |
| Newsprint | 24 000 | 24 000 |
| Other papers | 42 000 | 49 000 |
| *Raw materials for newsprint* | | |
| Unbleached sulphite pulp[b] | 2 380 | 2 380 |
| Mechanical pulp | 21 720 | 21 720 |
| Waste | 1 850 | 1 850 |
| | 26 400 | 26 400 |
| *Raw materials for other papers* | | |
| Bleached wood pulp | 6 430 | 7 500 |
| Bleached straw pulp | 8 060 | 9 410 |
| Unbleached sulphite pulp[b] | 7 350 | 8 580 |
| Unbleached Kraft pulp | 8 690 | 10 140 |
| Mechanical pulp | 10 080 | 11 760 |
| Waste paper and rags | 8 110 | 9 460 |
| | 48 720 | 56 850 |
| *Total A* | 72 120 | 83 250 |
| *Summary* | | |
| I. *Bleached pulps* | 14 490 | 16 910 |
| Wood | 8 060 | 9 410 |
| Straw and short fibre | 6 430 | 7 500 |
| II. *Unbleached pulps* | 18 870 | 21 550 |
| Sulphite | 10 180 | 11 410 |
| Kraft | 8 690 | 10 140 |
| III. *Grand total, chemical pulps* | 33 360 | 38 460 |
| IV. Mechanical pulp | 31 800 | 33 480 |
| V. Waste | 9 960 | 11 310 |
| *Total B* | 75 120 | 83 250 |

[a] Estimate made in 1950.
[b] This raw material, previously imported, will be replaced by domestic fibres (Kraft bleached pulp). The necessary tests have been made to prove that no technical difficulties will arise as a result of the change.

### Table 48

CASE 18. PROJECTED PULP PRODUCTION

*(Tons)*

| | *1955* | *1960* |
|---|---|---|
| *Bleached pulp 84-99% G.E.*[a] | | |
| Kraft (new plant) | 9 490 | 8 660 |
| Straw (existing plant) | 6 500 | 7 500 |
| Total bleached 84-89% G. E. | 13 990 | 16 160 |
| *Bleached pulp 64-69% G. E.*[a] | | |
| Kraft (new plant) | 9 660 | 10 660 |
| Unbleached Kraft pulp | 8 690 | 10 140 |
| Total bleached 64-69 G. E. | 18 370 | 20 800 |
| Grand total, domestic pulp | 32 360 | 36 960 |
| Imported pulp | 1 000 | 1 500 |
| Total pulp requirement (according to table 47) | 33 360 | 38 460 |
| *Distribution of domestic production* | | |
| New plant | 25 860 | 29 460 |
| Existing plant (straw) | 6 500 | 7 500 |

[a] The percentage G. E. is the international bleaching comparison standard.

### Table 49

CASE 18. PULP PRODUCTION SCHEDULE, 1954-1960[a]

*(Tons)*

| *Year* | *Total production* |
|---|---|
| 1954 | 10 000 |
| 1955 | 26 000 |
| 1956 | 26 500 |
| 1957 | 27 000 |
| 1958 | 28 000 |
| 1959 | 30 000 |
| 1960 | 30 000 |

[a] Round figures.

### Table 50

CASE 18. YIELDS OF DIFFERENT KINDS OF PULPS

*(Cubic metres per ton of wood)*

| | |
|---|---|
| Unbleached pulp | 5.00 |
| Bleached pulp | 5.35 |
| Weighted average (2/3 bleached, 1/3 unbleached) | 5.23 |
| Dry mechanical pulp | 2.80 |

**Table 51**

CASE 18. TOTAL AMOUNT OF WOOD REQUIRED FOR THE PROJECTED PULP PRODUCTION, 1954-1960

*(Solid cubic metres)*

| Year | Pulp | Newsprint | Other papers | Total |
|---|---|---|---|---|
| 1954 | 52 300 | — | 26 900 | 79 200 |
| 1955 | 136 000 | 60 800 | 26 900 | 225 000 |
| 1956 | 138 600 | 60 800 | 26 900 | 228 400 |
| 1957 | 141 200 | 60 800 | 26 900 | 231 900 |
| 1958 | 146 500 | 60 800 | 26 900 | 238 200 |
| 1959 | 151 700 | 60 800 | 26 900 | 244 400 |
| 1960 | 157 000 | 60 800 | 26 900 | 250 700 |

**Table 52**

CASE 18. PINE PLANTATIONS IN THE AREA

*(Thousands of hectares of pines)*

| Planted forests | Census | Plantations of the enterprise[a] | Total |
|---|---|---|---|
| In 1916 | 2 | — | 2 |
| 1917-19 | 108 | 22 | 130 |
| 1920-22 | 211 | — | 211 |
| 1923-25 | 313 | — | 313 |
| 1926-28 | 775 | 2 | 777 |
| 1929-31 | 1 460 | 51 | 1 511 |
| 1932-34 | 2 926 | 58 | 2 984 |
| 1935-37 | 8 519 | 17 | 8 536 |
| 1938-40 | 14 613 | 35 | 14 648 |
| 1941-43 | 14 155 | 1 560 | 15 715 |
| 1944-46 | 16 915 | 921 | 17 836 |
| 1947-49 | No details available | 605 | 605 |
| Not determined | 111 | — | 111 |
| *Total* | 60 108 | 3 271 | 63 379 |

[a] Not included in the census.

**Table 53**

CASE 18. AREA AVAILABLE IN THE VARIOUS ZONES

*(Hectares)*

| | |
|---|---|
| Zone 1 | 21 130 |
| Zone 2 | 33 809 |
| Zone 3 | 4 267 |
| Zone 4 | 4 173 |

**Table 54**

CASE 18. TOTAL WOOD AVAILABLE FOR PULP

*(Solid cubic metres)*

| | |
|---|---|
| 1949-51 | 186 090 |
| 1952-54 | 330 880 |
| 1955-57 | 589 470 |
| 1958-60 | 869 070 |
| 1961-63 | 639 000[a] |
| 1964-66 | 707 600[a] |

[a] Excluding thinnings, since there is no data to show recent plantations which will reach thinning age by that date.

**Table 55**

CASE 18. PROBABLE WOOD PRODUCTION AND CONSUMPTION

*(Thousands of solid cubic metres)*

| Year | Requirements of projected production | Probable production[a] | | |
|---|---|---|---|---|
| | | Thinnings | Final cut (40%) | Total |
| 1954 | 79 | 195 | 136 | 331 |
| 1955 | 225 | 209 | 380 | 589 |
| 1956 | 228 | 209 | 380 | 589 |
| 1957 | 232 | 209 | 380 | 589 |
| 1958 | 239 | 238 | 631 | 869 |
| 1959 | 244 | 238 | 631 | 869 |
| 1960 | 251 | 238 | 631 | 869 |

[a] For pulp alone.

(ii) Specification of domestic raw materials which, according to the project, would replace imported items.

(iii) Determination of the total quantities of domestic and imported fibrous raw materials required annually for paper production (table 47).

(iv) Preparation of the plan for annual domestic production of pulp according to the production programme (table 48) and a summary of the annual development of total pulp production (table 49).

(b) *Wood*

(i) Determination of the demand for wood for pulp production: unit consumption of chemical and mechanical pulp, and total consumption by years (tables 50 and 51).

(ii) Determination of the source and type of wood which must be used: available areas and distribution of the plantations by provinces, districts and communes, showing the age of the plantations (table 52).

(iii) Estimate of the yield of timber from the forests in various zones and determination of the possible volume obtainable from the areas indicated (tables 53 and 54).

(iv) Comparison between available timber resources and the amount required for the projected production of pulp and paper (table 55).

(v) Determination of the amount of timber (forest area and rotation) available from other suppliers, bearing in mind that the enterprise has its own forest in the region.

(c) *Other input items*

The other raw materials examined were: limestone, sodium sulphate, chlorine, caustic soda and coal. Unit consumption of each was specified, and the sources were indicated. Chlorine and soda would be produced by the enterprise in its own electrolytic plant.

The details given below show the minute detail in which the timber supply problem was examined, since wood is the basic raw material.

### 2. *Fibrous materials*

Table 48 shows projected pulp production, classified into two types: bleached 84-89 per cent G.E. and bleached 64-69 per cent G. E. The former would replace the unbleached sulphite pulp in table 47, which is normally imported. Of the 14 490 tons of bleached pulp required in 1955 according to table 47, 13 990 would be produced in the country, 7 490 in the new plant and the remaining 500 would be imported. Domestic production would supply 18 370 tons of unbleached pulp, leaving only 500 of the total of 18 870 to be imported. The estimates were made for each year, but table 48 shows only 1955 and 1960.

The schedule for the new pulp production would be as outlined in table 49.

### 3. *Timber*

(a) *Demand*

Laboratory tests showed that the quantities of timber indicated in table 50 would be needed to obtain the required amount of pulp.

Given the total amount and different kinds of pulp to be produced in the various years, the timber (pine) demand can be calculated. For example, 136 000 m³ would be needed in 1955 and 157 000 in 1960, to attain the projected pulp production.

The total number of cubic metres of timber required is shown in table 51.

The timber will be obtained from existing insignis pine plantations. The zone where the projected factory would be installed has forest reserves as shown in table 52.

(b) *Forest yield*

The following timber yields from the forest were calculated:

(i) In plantations near the coast, at 20 years, it is possible to obtain 400 m³ of timber for pulp per hectare.

(ii) From the inland plantations, 260 m³, at 20 years.

(iii) Thinnings will yield 40 m³ per hectare at 14 years.

In order to determine the probable production of insignis pine pulp with these yields, the plantations were grouped into 4 zones, and the available area per zone was determined (table 53).

Within each zone, the area was sub-divided by ages.

On the basis of this table, probable timber production for 1951-1956 was determined with the previously mentioned yields. Thinning would take place at 14 years, and clear cutting at 20. Of the clear cut, 60 per cent would be sent to sawmills and the remaining 40 per cent used for chemical and mechanical pulp, charcoal, etc.

In this way the total availability of timber can be calculated, as seen in table 54.

The comparison between expected total consumption and probable production is given in table 55.

The above figures show that there are ample timber supplies, even allowing for other uses, since it has been accepted that 60 per cent will be sent to sawmills.

From the geographical arrangement of the plantations it may be seen that the availability of timber increases towards the interior and decreases towards the coast, so that the factories would tend to obtain their supplies from inland.

Since the enterprise itself owns some plantations, an additional estimate was made of their production, the amount to be bought from other producers and the annual rate of forest development which would be necessary to produce that timber. The project also included further data in support of the argument that adequate supplies of the necessary raw material were available.

### 4. *Other materials*

(a) *Limestone*

High 90-95 per cent quality was specified. The source of supply, chemical analyses and delivery point were indicated.

(b) *Sodium sulphate*

It was shown that there are ample supplies from domestic sources. The most probable sources and analysis were indicated.

(c) *Chlorine and caustic soda*

An electrolytic plant will be installed which will supply other industries in the region from its excess production. The plant will produce:

| | Tons per year |
|---|---|
| Chlorine | 1 800 |
| Caustic soda | 2 000 |
| Hydrogen | 567 |

The annual requirement will be for 3 200 tons of sodium chloride and 6 million kWh. This plant will have 1 433 tons of caustic soda available for sale to other consumers (the surplus over the 600 tons needed by its own factory). All the chlorine will be used in the factory. The sodium chloride will be obtained from sources within the country; a chemical analysis of the raw material is included.

(d) *Coal fines*

The following quantities will be needed, to be obtained from local mines:

| | Tons per year |
|---|---|
| Pulp plant | 3 600 |
| Paper plant | 18 500 |
| Total | 22 100 |

(e) *Water*

Two types of water will be required:

(i) Industrial water:

| | Litres per second |
|---|---|
| Pulp plant | 1 250 |
| Paper plant | 150 |
| Total | 1 400 |

An analysis is given of water which may be obtained from nearby river.

(ii) Water for household consumption: The plant will require some 30 employees and 190 manual workers, who, with their families, will constitute some 1 000 persons. With an estimated consumption of 250 litres daily per person, the total consumption will be 250 m$^3$ daily, or 3 litres per second.

(iii) Irrigation water: It is estimated that 50 hectares will be irrigated. At 1.2 litres per second per hectare, 60 litres per second will be required.

The total water requirements will therefore be 1 463 litres per second, which should be increased to 2 000 to allow a safety factor. When these figures are compared with the flow of the nearby river, it will be seen that the supplies are sufficient.

## *Case 19*

### Examination of the raw material supply for a beet-sugar factory

The study of one project often leads to the study of another or others which prove to be more important than the original. An example of this may be seen in the following case.

A beet sugar factory depends basically for its raw material on local production. In the case in point, research was carried out over five years on the cultivation of the sugar beet. The research covered different areas, seeds, growing methods, sowing and harvesting times and other matters. The data thus obtained were tabulated in a form which showed the influence of these factors on roots, leaves and crowns per hectare, sucrose content, and the other important technical and economic characteristics.

The studies showed that there were favourable prospects of introducing this type of cultivation over a very wide area, and also indicated the best district for installing the first plant.[21] In this district a detailed economico-agricultral study was made, since, after it had been made clear that the natural resources were satisfactory for growing, it had to be shown that it was justifiable from the economic aspect too. Special surveys were made on background data, such as: the existing degree of mechanization, dairy development in the area, transport problems, habitual crop rotation, possible competitive crops, etc. The findings of the survey confirmed that conditions were entirely favourable both from the farmer's and the social points of view.[22]

Once it had been decided to install a factory in the area, a programme had to be arranged to grow the crop locally. The industrial project was divided into two: one properly speaking industrial, and one agricultural. To justify the industrial project, more emphasis was placed on the agricultural aspect, in spite of the undeniable interest of the industrial phase.

Although the project originated as a plan to replace imported sugar and thereby to ease the balance-of-payments situation, as the studies advanced it became obvious that, in addition to being decisive, the agricultural aspect was as attractive as the industrial if not more so.

The supply of raw material became the main problem of the industrial project. An agricultural project had to be drawn up in order to solve it.

## *Case 20*

### Description and budget of an irrigation project for 50 000 hectares

This was a project of the Peruvian Government to irrigate an additional 50 000 hectares in the Piura-Quiroz region in the north of Peru, and to ensure the supply of irrigation water for land already cultivated in the region. The general technical characteristics of the project clearly show the type of studies needed, both from the hydraulic and the agronomic and soil aspects. The method of calculating the budget is outlined here and some details are given concerning the future administration of the project which are closely related to the technical aspects.

#### 1. *The Piura-Quiroz development project*

The River Piura is an erratic stream which is dry for the greater part of the time. The basin covers some 2 800 km$^2$ and is relatively low-lying, and the rainfall it receives varies considerably. Studies show that it is highly unlikely that a suitable place can be found for large-scale river control. As irrigation of the upper part of the valley has increased, water availability has decreased in the lower part. During the drought of 1950-1951 and 1954, the

[21] See case 25.

[22] In case 39, a general list is given of background data required for farming projects.

river remained completely dry for long periods. The frequent water shortages impeded the effective use of the land for cultivating Pima cotton, which is an important export commodity.

The only practical method of obtaining additional water for the lower part of the valley is to divert the River Quiroz close to the valley. This river rises at an altitude of 4 000 m, and has a drainage basin of some 2 300 km² which lies above the proposed canal. Although the flow varies considerably, the current is always strong. Hydrological studies showed that the system for diverting the waters of the Quiroz should have a capacity of 60 m³ per second, which is the most economic solution. On this basis an average of 765 million m³ of water could be diverted annually from the Quiroz; the minimum would be 340 million, according to data for 1954, the driest year recorded. This quantity is more than that required to supplement the supply in the lower Piura valley. Nevertheless, during February, which is generally the planting month, the flow is less than is needed. The project therefore includes a reservoir to store the excess water, thus ensuring a supply both in the critical season and in dry years and making possible the irrigation of a greater area between the rivers Chira and Piura.

## 2. *Progress to date*

The development of the irrigation plan was in two stages. During the first, additional water was supplied to the land already cultivated in the Piura valley. The second stage will irrigate 50 000 ha of dry land between the rivers Chira and Piura and ensure a good supply of water for the cultivated land in Piura.

The execution of the first stage was started by the Peruvian Government in 1949. In May 1951, the project was handed over to a firm of contractors for completion, and in December 1953 the system was put into operation. The work consisted in the construction of deflectionary walls in the Rivers Quiroz and Chipillico, 19 km of lined canal, 8.6 km of lined tunnels and some 50 km of improved watercourse. At this stage the water of the Quiroz was diverted to the Piura.

Total construction costs were approximately 11 million dollars, including the equivalent in dollars of the national currency expended. It was originally estimated that these works would increase the average cultivated area by 11 000 ha (from 15 000 to 26 000), but the estimate was too cautious. In spite of the fact that 1954 was a very dry year (the River Piura was almost completely dry from March) and that the flow of the Quiroz was well below 760 million m³, the waters diverted by the canal were sufficient to irrigate 31 000 ha of the Piura valley. This was due to a more economic use of water under a new regulation which required the payment of 2 centavos per cubic metre of irrigation water, which previously had been free. As a result of this regulation, water is used more carefully, and more hectares can be served.

The second stage consisted in constructing 95 km of lined canal, with a capacity of 50 m³ per second, some 70 km of lined canal with capacity of 25 m³ per second, some 320 km of distribution canals and associated structures. The diversionary canal for the water of the Quiroz constructed in the first stage, will form part in the overall programme, since it will carry water to the reservoir.

The new irrigated lands between the Rivers Piura and Chira are mainly arid, although in some areas there is extensive animal husbandry (one animal per 10 or 20 ha).

A detailed soil study has been made to select finally the land to be included in the project. Some 56 000 ha of irrigable land will be covered, of which some 10 per cent, or about 6 000 ha, occupied by roads, ditches, houses, etc., must be considered unproductive. This leaves a net total area of 50 000 ha, in which three general types of soil are represented.[23]

The Tablazo series of soils (22 000 ha) is often sandy and especially suitable for growing Pima cotton, or other long-fibre types. These soils have good water retention and good drainage. Some 15 per cent are suitable for low-cost cultivation, and 85 per cent at the average cost for the region.

The remaining 34 000 ha are of the Tambo Grande and Yuscay-Tejedores series, in the regions bearing the same names. The Tambo Grande soils are sandy or silty loam, with sandy or sandy-loam subsoils. They are fertile and suitable for a variety of crops and for irrigated pasture. Cotton may also be grown in them. The cost of soil preparation will be average or low.

The Yuscay-Tejedores soils are mainly sandy loam, with clay-loam or silty-loam subsoils. They are suitable for crops similar to the Tambo Grande soils, except cotton which might be contaminated by insects from the trees and bushes on the neighbouring hillsides. They are also somewhat heavy for cotton.

It was assumed that 15 000 ha in the Tablazo region would be planted with cotton and 5 000 with crops. The Tambo Grande will have 5 000 ha of cotton. There will thus be a total of 20 000 new ha of cotton and 30 000 of crop and livestock production.

## 3. *Availability of water*

The land at present cultivated in the Piura valley needs 320 million m³ of water annually and the new area 560 million (880 million in all). During a normal year, 185 million m³ will be available from the River Piura; the remainder will be supplied from the Quiroz, either direct, or from the reservoir.

As previously explained, 765 million m³ must be tapped from the Quiroz each year. The reservoir will have a capacity of 250 million m³ and will make control possible; this is necessary because the available water does not coincide with the requirements throughout the year. In a dry year, water will be taken from the reservoir to supplement the flow from the river.

The two rivers will seldom be at minimum flow at the same time, but even in this case available statistics show that there may be a shortage only one year in four, with a maximum shortage of 40 per cent during one year in 16, which is considered acceptable for this type of project. It was also noted that the calculations of requirements are based on earlier irrigation data, which were excessive; the farmers may be more sparing in their use of water in future.

No allowance has been made for recovered water, which will be available after the new land is in cultivation. Up to 70 million m³ may be recovered each year, which is sufficient to irrigate 7 000 to 10 000 ha without any further investment. The evaluation of the project also left out

[23] See case 39, for information on the process of soil classification.

Table 56

CASE 20. ESTIMATED COST OF THE IRRIGATION PROJECT

*(Equivalent of millions of dollars)*

| | Foreign exchange | National currency | Total |
|---|---|---|---|
| A. *Dam and reservoir* | | | |
| Local labour (including social insurance) | — | 2.10 | 2.10 |
| Contractors' personnel | 0.75 | 0.12 | 0.87 |
| Equipment | 2.40 | 0.26 | 2.66 |
| Materials and supplies | 2.54 | 1.14 | 3.68 |
| Insurance | 0.11 | 0.06 | 0.17 |
| Freight | 0.26 | 0.06 | 0.32 |
| Subsistence allowances | 0.09 | 0.01 | 0.10 |
| Contractors' fees | 0.61 | 0.26 | 0.87 |
| | 6.76 | 4.01 | 10.77 |
| B. *Canals and lateral system* | | | |
| Local labour (including social insurance) | — | 2.70 | 2.70 |
| Contractors' personnel | 0.98 | 0.14 | 1.12 |
| Equipment | 3.10 | 0.34 | 3.44 |
| Materials and supplies | 3.28 | 1.50 | 4.78 |
| Insurance | 0.14 | 0.09 | 0.23 |
| Freight | 0.34 | 0.09 | 0.43 |
| Contractors' subsistence allowances | 0.11 | 0.01 | 0.12 |
| Contractors' fees | 0.79 | 0.34 | 1.13 |
| | 8.74 | 5.21 | 13.95 |
| C. *Other expenses* | | | |
| Expropriations | — | 0.50 | 0.50 |
| Interest during construction | 1.76 | 0.64 | 2.40 |
| Engineering and inspection | 0.45 | — | 0.45 |
| Contingencies | 0.29 | — | 0.29 |
| | 2.50 | 1.14 | 3.64 |
| Grand total | 18.00 | 10.36 | 28.36 |

the more certain supply of irrigation water in the areas at present cultivated.

The cost of the project is shown in table 56.

The foreign exchange component of the investment in the budget is possibly somewhat high. This is mainly due to the following factors: (*a*) the high cost of imported materials compared to total cost for the main canals; (*b*) the amount of heavy equipment required to complete the work within a reasonable period; and (*c*) the probability that 90 per cent of the personnel employed by the contractors and 70 per cent of the fees must be paid in foreign currency.

In addition to the figures given in table 56, the Peruvian Government has already invested the equivalent of some 4 million dollars. The cost of the second stage will thus be 32 million dollars.

### 4. *Organization and administration of the Department of Water and Irrigation*

The distribution of water in all the coastal and mountain irrigated areas is the responsibility of the Department of Water and Irrigation (*Dirección de Aguas e Irrigación*), a Government department of the Ministry of Development and Public Works (*Ministerio de Fomento y Obras Públicas*). The Department has been engaged since 1919 in the development of a total of 53 000 new ha to be brought under cultivation. The largest project was Jauja (11 000 ha), which was completed in 1952. The Quiroz-Piura project includes the establishment of an autonomous irrigation district subject to inspection by the Department. The administration will supply the water as required, will collect payment, take charge of maintenance of the works and recommend any legislative measures which may be considered necessary for the control and development of the project.

Since this is the largest irrigation project ever undertaken in Peru, it was expected that serious problems would arise regarding the administration of the reservoir, the distribution of water and the re-use of recovered water. The Government agreed to the contracting of the services of an experienced consulting inspector who would advise the project administration, at least during the first few years.

At the same time, the Ministry of Agriculture proposes to establish two experimental and demonstrative farms in the area. One of them, covering 20 ha, will be situated in the cotton zone and will concentrate on studies on cotton-growing. Another, of 30 ha, will deal with farming problems connected with food crops. Both of these experimental farms will be operated commercially.

## *Case 21*

### INFLUENCE OF THE CHANGE OF FUEL AND OF THE SOURCE OF RAW MATERIALS ON PRODUCTION COSTS AND STEEL QUALITY IN AN IRON AND STEEL MILL

This case is taken from studies for the expansion of an iron and steel mill and shows the possible effects of technical changes on the evaluation of a project. It deals in a general way with the expansion of the production of a mill from 300 000 to 560 000 tons yearly, bearing in mind a probable further expansion to 1 million tons. In addition to the actual plant expansion, the project also anticipates a change in the source of fuel and iron ore in order to improve output quality and decrease production costs. Each of these changes is a project in itself, which, although related to the other studies, may be approached and presented separately.

It is proposed to replace the domestic fuel at present used by natural gas, also domestic. There is a project to begin working a new mine, owned by the enterprise, which would supply ore to replace that from the present supplier. The examples given below refer to these two supplementary projects and show the influence that technical changes may have on a project.

### 1. *Change of fuel*

The conversion process in the steel plant was complicated by the high sulphur content of the fuel oil (average 4 per cent) to the point where it became necessary for a time to import fuel.

After many tests, it was found possible to begin the conversion process by using a low-calory light oil to melt the charge in the open hearth furnace and afterwards to use the higher-calory, high sulphur oil. In this way a steel of satisfactory quality could be made, although with a loss of output, which meant lower tonnage per hour from the open hearth, a lower proportion of ingots per charge and heavier wear on the refractories.

The use of low-sulphur fuel would increase the output from the same furnaces by 5 to 10 per cent of better quality steel, which in itself would be a considerable advantage. In the case presented to justify the project, however, no attempt was made to weigh this advantage, since the other factors were sufficient to prove its merits. The change of fuel, which could be achieved by means of a 248-mile gas pipeline between the natural gas wells and the plant, implied sufficient savings to justify the investment.

At the projected expanded output rate, blast furnace gas could be use to generate electric power, and 16.25 million cubic feet of natural gas would also be required daily. Fuel-oil at present costs the enterprise 30 (dollar) cents per million BTU at the plant, whereas natural gas would cost only half of this. Hence, at an annual production rate of 560 000 tons of steel, savings would amount to 800 000 dollars. Available technical data show that gas reserves should meet the steel plant's needs for 20 years at least.

The gas pipe-line would be the property of the steel plant and would cost 3 560 000 dollars, of which 2 507 500 would be for the purchase of imported pipes, valves, etc., while the remainder would be the equivalent of expenses in local currency. Without pumps, the line could supply the 16 million cubic feet required daily for the projected production, including the transformation of 560 000 tons of steel ingots into finished products.

It would be possible later to instal two pumping stations, which would increase the line's capacity to 32 million cubic feet daily, sufficient to produce 1 million tons of steel per year.

In order to determine the natural gas requirements and the extent of the savings, the technical study presented a series of thermal balance sheets for varying annual steel production. Table 57 gives examples for outputs of 560 000 and 1 million tons of steel per year.

### 2. *Change of ore*

The increase in steel production could be obtained using the present ore, but the technical and economic advantages of opening a new deposit led to the inclusion of the project within the expansion programme.

The ore at present used has a high iron content and little sulphur, and can be obtained at reasonable prices. If, however, it is used to provide the entire ferrous charge of the furnace, the resulting pig iron contains approximately 1.15 per cent phosphorus. This is a medium quality product, with a phosphorus content too high for the satisfactory operation of an open hearth (Siemens Martin) and to low to use in a basic converter (Thomas). The enterprise has to use a maximum of 80 per cent of this ore, completing the charge with a phosphorus-free ore from small mines which does not guarantee a continuous supply.

The uncertainty of achieving a parallel increase in the output of the large number of small mines producing low-

**Table 57**

CASE 21. SUMMARY OF HEAT BALANCE

*(Millions of BTU per day)*

| | *Annual production capacity in thousands of tons* 560 | 1 000 |
|---|---|---|
| *Heat required* | | |
| I. For direct production | 12 772 | 22 840 |
| II. To generate electric energy | 9 000 | 16 250 |
| III. To produce steam for blowing the blast furnace | 2 948 | 4 600 |
| IV. To produce steam for other operations | 2 500 | 5 800 |
| V. Total heat required | 27 220 | 49 490 |
| VI. Total available from blast furnace gases | 12 000 | 19 700 |
| VII. Thermal requirements obtained from natural gas | 15 220 | 29 790 |
| VIII. Equivalent in cubic feet of category VII gas (1 cubic foot = 936 BTU) | 16 250 000 | 31 900 000 |

phosphorus ore constitutes an obstacle to the expansion plan. The new mines proposed in the project solve the problem satisfactorily since they enable pig iron of 0.23 per cent phosphorus to be obtained as compared with the 0.70 per cent resulting from the 80 per cent high-phosphorus and 20 per cent low-phosphorus mixture. The cost of the ore would be approximately the same as for that used at present, and the iron content would be the same, but without the drawbacks arising from the phosphorus.

The new pig-iron quality would save one hour in each open-hearth charge, and with six furnaces working this means an annual saving of 4 160 hours of open-hearth operation.

A most cautious estimate would give an average of 10 tons of steel ingot per hour of open-hearth operation.

The direct savings resulting from the use of the new ore are estimated as follows:

| | *Dollars* |
|---|---|
| (a) Saving of one hour of heat per charge of steel (4 160 hours annually) at 28 dollars per hour ............................ | 116 500 |
| (b) During these 4 160 hours, an output increase of 10 tons per hour may be estimated, which gives an annual production increase of 41 600 tons; with 70 per cent efficiency, an additional 29 200 tons of steel would be obtained. The profit on this production would be the difference between the direct production costs and the net selling value, since all overhead would be covered by present production. If the difference is taken at 48 dollars per ton, this would give an annual saving of ............................ | 1 400 000 |
| Total | 1 516 000 |

Apart from these benefits, the increased assurance of supply and the better quality of the product were taken into account.

The operation of the mine would require a railway to be constructed, which must be charged to the project. The total investment for the purchase of properties, equipping the mine and constructing the railway would be 8 113 200 dollars, of which 3 214 000 represents expenses in local currency.

*Case 22*

TECHNICAL PROCESSES AND THE INDUSTRIAL COMPLEX IN A PROJECT FOR THE PRODUCTION OF METALLIC ZINC

This case is based on an investment project for making metallic zinc and ammonium sulphate and is an example of the way in which industrial complexes are formed. The chief activity of the plant is to extract zinc from ore and to produce a nitrogen fertilizer. These operations are connected because a by-product of the zinc process is used to make the fertilizer. Zinc production takes place in one factory, while the fertilizer requires three. The four units in question are:

(1) Zinc plant
(2) Sulphuric acid plant
(3) Ammonia plant
(4) Fertilizer plant, where the ammonia is combined with the sulphuric acid to make ammonium sulphate.

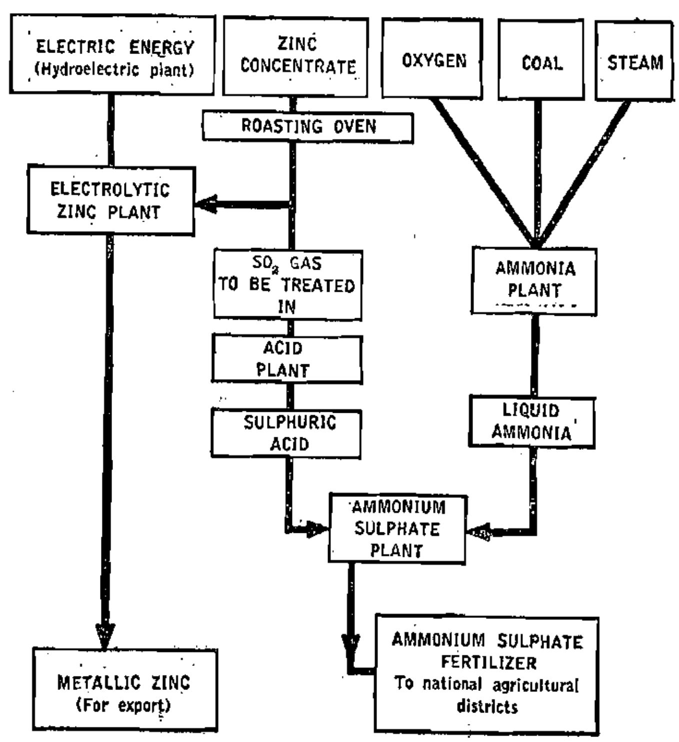
The establishment of the industrial complex around the zinc production is based on both economic and technical criteria. The zinc concentrates, which constitute the raw material for producing zinc, contain sulphur which must be removed before the zinc is separated. This is achieved by means of a roasting process, which releases the sulphur in gaseous form, and the dissipation of this gas in the atmosphere creates serious problems, especially in view of the fogs and drizzles in this area in winter. The chemical reaction of the sulphurous gas with the damp air produces sulphuric acid, which is corrosive and attacks both metals and vegetation. If the gases produced during the roasting are utilized, all these problems are eliminated. The availability of the sulphuric acid and the need for nitrogen fertilizers led to the inclusion of a study on an ammonium sulphate plant.

No special analysis was made of size or site. As regards the former, it was merely stated that some 112 short tons of metallic zinc would be produced daily. The acid plant could utilize all the sulphurous gases from the zinc production; the fertilizer plant, converting the acid and ammonium sulphate, would produce about 269 tons daily. The project mentions that similar industrial complexes based on zinc production have been successful.

The process consists of first roasting the concentrates to eliminate the sulphur in the form of sulphur dioxide; the residue is leached to make a zinc sulphate solution, which in turn is processed electrolytically to recover the acid and to produce metallic zinc. The project gives detailed descriptions of the production processes for the acid, ammonia and sulphate. Flow sheets and some chemical equations are given to clarify the explanation. A detailed list of the equipment required in each plant is also included as well as a diagram of the industrial complex (see figure 3).

**Figure 3**

CASE 22. OUTLINE OF THE INDUSTRIAL COMPLEX, ELECTRIC ENERGY, PRODUCTION OF ZINC AND OF NITROGENOUS FERTILIZERS



# Table 58

## CASE 23. WORK SCHEDULE

*Approval of project* during first half of March 1954
*Placing of order* for machinery abroad during first half of May 1954

| | 1954 | | | | | | | | | | | | 1955 | | | | | | | | | | | | 1956 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M |
| *Engineering* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Requests for tenders | | x | | | | | | | | | | | | | | | | | | | | | | | | | |
| Studies on site | | x | x | | | | | | | | | | | | | | | | | | | | | | | | |
| Planning of work | | x | x | | | | | | | | | | | | | | | | | | | | | | | | |
| Site layout | | x | x | | | | | | | | | | | | | | | | | | | | | | | | |
| Provisional quantifying of basic materials | | x | x | x | | | | | | | | | | | | | | | | | | | | | | | |
| Ordering of basic materials | | | x | x | | | | | | | | | | | | | | | | | | | | | | | |
| Planning of temporary connexion | | | x | | | | | | | | | | | | | | | | | | | | | | | | |
| Architecture | | | x | x | | | | | | | | | | | | | | | | | | | | | | | |
| Planning of street works | | | | | x | x | x | x | | | | | | | | | | | | | | | | | | | |
| Planning of rail sidings | | | | | x | x | x | | | | | | | | | | | | | | | | | | | | |
| Planning of final electrical connexion | | | | | | | | x | x | | | | | | | | | | | | | | | | | | |
| Planning of water purification | | | | | | | | x | x | | | | | | | | | | | | | | | | | | |
| Planning of metallic structures | | | | | x | | | | | | | | | | | | | | | | | | | | | | |
| Calculation of metallic structures | | | | | | x | x | | | | | | | | | | | | | | | | | | | | |
| Machinery planning | | | | | | x | x | | | | | | | | | | | | | | | | | | | | |
| Foundations calculations | | | | | | | x | x | | | | | | | | | | | | | | | | | | | |
| Planning of auxiliary buildings | | x | x | x | x | x | x | | | | | | | | | | | | | | | | | | | | |
| Other engineering studies | | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | | | |
| *Construction and installation* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Work installations | | | x | x | | | | | | | | | | | | | | | | | | | | | | | |
| Site preparation | | | x | x | x | | | | | | | | | | | | | | | | | | | | | | |
| Temporary electrical connexion | | | | x | | | | | | | | | | | | | | | | | | | | | | | |
| Temporary industrial water purification | | | | x | x | | | | | | | | | | | | | | | | | | | | | | |
| Placing basic materials on site | | | | x | x | | | | x | x | | | | | | | | | | | | | | | | | |
| Placing other materials on site | | | | | | | | | x | x | x | x | x | x | x | x | x | x | x | x | | | | | | | |
| Final drinking water installation | | | | | | | | | x | x | | | | | | | | | | | | | | | | | |
| Housing estate and street work | | | | | | | | | x | x | x | x | x | x | x | x | x | x | x | x | | | | | | | |
| Surrounds | | | | | | | | | x | x | x | | | | | | | | | | | | | | | | |
| Workshops | | | | | | | | | x | x | x | | | | | | | | | | | | | | | | |
| Installation of workshops | | | | | | | | | | | x | | | | | | | | | | | | | | | | |
| Offices | | | | | | | | | x | x | x | x | x | x | x | | | | | | | | | | | | |
| Plant foundations | | | | | | | | | x | x | x | x | | | | | | | | | | | | | | | |
| Final installation of industrial water | | | | | | | | | | x | x | x | | | | | | | | | | | | | | | |
| Rail sidings | | | | | | | | | | | x | x | x | | | | | | | | | | | | | | |
| Silos | | | | | | | | | | | x | x | x | x | x | | | | | | | | | | | | |
| Warehouses | | | | | | | | | | | x | x | x | x | | | | | | | | | | | | | |
| Gate-houses, shelters, etc. | | | | | | | | | | | x | x | x | x | x | | | | | | | | | | | | |
| Garage and machine bay | | | | | | | | | | | | x | x | x | | | | | | | | | | | | | |
| Structures and roof of plant | | | | | | | | | | | | x | x | x | x | x | | | | | | | | | | | |
| General filling and finish of plant structure | | | | | | | | | | | | | | x | x | x | | | | x | x | x | | | | | |
| General installation | | | | | | | | | | | | | | | x | x | x | x | x | x | x | x | x | x | x | | |
| Final electric connexion | | | | | | | | | | | | | | x | x | | | | | | | | | | | | |
| Paving | | | | | | | | | | | | | | | | | | | | | | | x | x | x | | |
| Tests | | | | | | | | | | | | | | | | | | | | | | | | | x | x | x |

## *Case 23*

### WORK SCHEDULE IN A BEET-SUGAR MILL PROJECT

The work schedule was summarized and presented in three parts (see table 58). The first covers engineering and begins with the invitation of tenders, to be submitted during the first half of February, so that the order be placed during the first half of May.[24] Site studies, planning of the work, site layout and preliminary estimates of the quantities of basic materials (gravel, sand, cement, iron and wood) also had to be started in February. Sufficient materials had to be accumulated by June (when weather conditions would stop work on the site) to be ready for work in September. The item "machinery planning" refers to sugar and by-product equipment layout in their respective buildings, to be arranged in collaboration with the equipment supplier.

All strain calculations, building designs, road and rail links and sidings, and civil engineering in general are included in this phase of the work. Table 58 indicates the need to organize the engineering office responsible for this work immediately, since the schedule was very tight (the plant was to be in operation in 1956).

The second part of the work schedule covers construction and installation proper. It is divided into three periods:

(1) From mid-March to June, when the work and site were to be prepared (earthmoving and levelling), a temporary electrical connexion was to be made, together with a provisional water installation, and basic materials were to be accumulated.

(2) It was assumed that during June, July and August work would be interrupted by the weather. During short periods of fine weather the accumulation of gravel and sand could probably continue and any small jobs could be done.

(3) As from September 1954, the construction was to begin: first the installation of drinking water, roads, road lighting, etc. on the site and the building of houses, fences, factory foundations, office and workshop accomodation.

The building of the structure and roof of the factory was to begin in December 1954. It was hoped that by then the first equipment would have been despatched by its manufacturers. Roofs were to be on by April, making use of the good weather. General installation was to start in April, and was to continue without interruption during the winter, since the main plant building would already be roofed.

The third part of the work schedule includes installation tests to be made during February and March simultaneously with the addition of the final installations.

The project mentions that the schedule is very tight and that the engineering must be well synchronized with the placing of the order, the delivery of the equipment from the suppliers and the accumulation of the basic materials. This is particularly important since it is impossible to work in the open during the winter. Further, the general supply problem is aggravated by the distance from supply centres. Anticipating these difficulties, the project-makers emphasized the importance of the first stage, up to June 1954, when the basic decisions had to be taken to ensure the execution of the programme.

[24] The original dates have been maintained in the interest of easier explanation.

## *Case 24*

### ESTIMATED LABOUR COSTS IN A MOTOR-CAR MANUFACTURING PROJECT

The following example has been taken from a project for the manufacture of medium-sized motor-cars and shows how labour requirements were calculated.

It was assumed in the study that 10 per cent of the monetary value of the motor-cars would be imported, and that a certain number of spare parts would be purchased from local industries. Taking into account these two considerations and the enterprise's experience in the country concerned, it was estimated that the factory to be installed would require 280 man/hours for production alone (finishing of parts and assembling) excluding what was termed in the project "indirect" and "auxiliary" labour.

The remainder of the direct labour input needed for production would be included in the 10 per cent of the value of imported motor-cars and in the parts to be supplied locally (see table 59).

On the basis of a working year of 250 days and an output of 40 vehicles per 8-hour shift, 1 750 hands would be required,[25] out of which 1 400 would be employed in direct production (manufacture and assembly), 210 in "indirect" services and 140 in "auxiliary" services.[26]

Lastly, still on the basis of experience acquired in the home factory, it was estimated that the number of employees would amount to 15 per cent of that of the workers, i.e., 260 persons.

The total labour force directly required for the project would therefore consist of 1 750 workers and 260 employees—a total of 2 010 persons.

[25] The figure may be calculated as follows: to produce 40 vehicles per day, 40 × 350 man/hours would be required, i.e., 14 000. To make up 14 000 man/hours into an 8-hour working day, $\frac{14\,000}{8}$ men would be needed which equals 1 750 persons.

[26] The method of classifying labour was not clearly indicated.

**Table 59**

CASE 24. ESTIMATED LABOUR INPUT PER MOTOR-CAR

*(Man/hours)*

| | |
|---|---|
| 1. Direct labour employed per vehicle | 280 |
| 2. Indirect labour required in the factory (empirically estimated at 15 per cent of direct labour) | 42 |
| 3. Auxiliary labour (10 per cent of direct labour) | 28 |
| Total per unit | 350 |
| Total required to produce 10 000 units per year | 3 500 000 |

## Chapter IV

## SIZE AND LOCATION OF PROJECTS

### I. The size problem

#### 1. *Size as related to other aspects of the project*

The size of a project usually means its production capacity during a normal operating period. For instance, if the size of a footwear factory is said to be 50 000 pairs per year, the proposed number of working days and working hours per day to attain this production must be specified.[1]

The need for reserve equipment, and provision for operating flexibility to meet demand fluctuations, mean that normal output will seldom be 100 per cent of installed capacity; the difference depends on the nature of the project.

Size is sometimes expressed in terms of the number of persons employed, or the capital involved, but these methods are more useful in comparing the size of units making different items than for alternative installations making the same product.[2] There are also some types of project which may be expressed in special units, such as spinning mills, measured by the number of spindles, and roads by width and length of surface area.

As in any other aspect of the project, the optimum size and the best location will be those which will lead to the most favourable economic result. This may be measured by any of the following coefficients:[3] profit per unit of capital (net return); minimum unit cost; sales-costs ratio; total profits. Measurement of any of these requires an estimation of all the aspects of the project, which leads to the process of successive approximations mentioned earlier.

Amongst the general reciprocal relations between the various aspects of a project, there are certain points concerning size which are of special interest, and which help to simplify this system of successive approximations.

Firstly, there is the relation ship between size and the market, where the dynamic nature of demand and its geographical distribution are of particular importance. Secondly, there is the relationship between size and the market, where the dynamic nature of demand and its geographical distribution are of particular importance. Secondly, there is the relationship between size and production costs, also known as the "economy of scale". Since production costs, including transport to place of consumption, will also be a function of location, and remembering the influence of geographical distribution of demand, the special connexion between size and location may be appreciated. Through their influence on production costs, the scale of the project and the location finally affect all the evaluation coefficients mentioned above.

To these reciprocal effects must be added those arising from technical, financial and other factors, which will be discussed briefly.

#### 2. *Size and the market*

The most important factor in determining the size of a project is normally the volume of demand to be met. Three fundamental situations have already been seen,[4] according to which either the volume of demand does not place any practical limitations on the scale of production, or it is so small that it does not justify the minimum economic production, or it is equal to that minimum possible size. Accordingly, the market study will be closely related to size in the third case; however, the volume of demand is not a limiting factor in the first case, and in the second it decisively prohibits the execution of the project.

The foregoing helps to outline the problem, but it becomes more complicated when taking into account demand as a function of income, prices, population factors, changes in the geographical distribution of the market and the influence of size on costs.

##### (a) *Dynamic nature of demand*

All industries have a characteristic curve of production costs as a function of size. Combining these cost curves with those of demand variation as a function of one or more of the factors just mentioned, it will often be possible to show the desirability of installing sizes greater than those corresponding to current demand. In the case of price, the greater size could be justified, for instance, since the lower costs would permit lower selling prices, which would in turn—because of a high price-elasticity—increase demand. An examination of the future growth of demand may justify the immediate installation of excess capacity, although it will operate at higher costs for some years—perhaps even at a loss during the early years—since the smaller profits may be more than compensated in subsequent years by the lower costs resulting from larger-scale production. This alternative would obviously only be justified in the case of an industry which is difficult to divide into partial production units, each of small capacity. Otherwise, it would be better to continue adding new small units along with the growth of the demand, without the necessity of maintaining idle capacity for a number of years. Furthermore, for a given size of plant, unit costs will decrease as a larger proportion of installed capacity is used.

In short, there are two types of cost curves as functions of quantities produced. One represents the unit costs of a series of differently sized plants, each working at 100-per-cent capacity; the other portrays the unit costs resulting

[1] There are cases where the specification of normal working hours is unnecessary, since the technical process requires continuous operation, stopping the equipment only for cleaning and preparation (for example: blast furnaces making pig iron).

[2] They are used, for instance, to show whether an industry is light or heavy. Thus it has been proposed that the heavy nature of an industry should be defined in accordance with: (*a*) the weight of material handled by each worker; (*b*) the value of a given weight of the product; (*c*) the cost of materials, expressed as a proportion of the gross value of production; (*d*) the proportion of male workers, and (*e*) the horsepower per worker. See P. Sargent Florence, *Investment, Location and Size of Plant,* Cambridge University Press, 1948.

[3] These coefficients are used for selection between alternatives, in the assumption that resources will be allocated to a specific end. In order to decide priorities between the various uses of such resources, other aspects must be considered. This problem will be discussed in Part Two.

[4] See chapter II.

when a plant of specific size operates at different percentage levels of its capacity.

Given a certain existing demand and an estimated growth in it, the size study is best based on a combined analysis of demand curves and unit cost curves as functions of size. The size of the satisfactory plant will be that yielding the minimum unit cost necessary to meet present demand and also having enough capacity to cover future demand.

The graphs and unit cost equations pertaining to this analysis will be explained later when dealing with break-even points in chapter VI.

(b) *Geographical distribution of the market*

The geographical distribution of the market may be a very important factor in decisions on plant size and location. Perhaps the same demand could be satisfied by (*a*) a single plant for the whole of the geographical market; (*b*) one central plant for the greater part of the territory with smaller branches in other places; and (*c*) several plants of the same size spread over the area.

Together with the size elements, those depending on the location will affect this decision; these will be discussed later.[5] Naturally, when considering locational effects, the scale must be analysed also in terms of delivery costs from the various distribution points.[6]

### 3. *Size, technique and investments*

From the technical aspect, it has already been mentioned that certain processes, or certain production techniques, require a minimum scale, below which the costs will be so high that it would be completely impossible to operate. Examples are automatic production, only applicable to a certain minimum scale, and many production processes. Suppliers of equipment offer only certain sizes, to which the solution must be adapted, so that practical limits are established.

The relation between size and technique in turn affect those between size, investment and labour costs. In fact, operation on a larger scale becomes mainly a question of a smaller investment per unit of installed capacity, and greater productivity of labour and other inputs. This not only helps to reduce production costs and increase profits, but also increases the net return, since the investment declines whilst profits are raised.[7]

### 4. *Size and location*

The basic relations between size and location arise on one hand from the geographical distribution of the market, and on the other from the influence of location on costs and on the evaluation coefficients. Because of scale economies, there will be a tendency to install a bigger plant, covering the largest possible market area. However, as the area served increases, distribution costs will rise because of higher freights and a point will be reached where the advantages of the bigger scale are outweighed.

[5] See section II of this chapter.

[6] The remaining evaluation coefficients mentioned earlier will also vary with these costs.

[7] If projects for the production of different goods or services are compared in terms of production per man, investment per man, or production per unit of capital, such a comparison would be affected by the scale of the various projects.

The various cost alternatives considered should be those at the point of distribution, and not the production costs at the plant. The influence of location costs will be dealt with in some detail later,[8] and mention will be made here only of some examples of limitations imposed by location on size.

If a location is sought for a milk plant, for example, the potential output of the milk-producing area supplying the plant will set a practical limit on the size. In turn, the limits of this area will be determined by the cost of transporting the milk from the farms to the plant. Given the transport costs and the price of the milk, the area's capacity for the supply of milk to the plant is known, and with this the maximum size of the plant. A similar situation occurs in the case of sugar mills using cane or sugar beet, in pulp and paper industries using wood, and in general, all industries which depend on agricultural raw materials that cannot be transported over long distances, because they are perishable, or bulky, or for other reasons.

### 5. *Size and financing*

If the available capital resources are insufficient to meet the capital requirements for a minimum size plant, the project must obviously be abandoned from the start. If, alternatively, the financial resources permit choice between different sizes, the cautious criterion would lead to the selection of a size which, given a satisfactory—although not necessarily optimum—evaluation may be financed with ease and security.

Problems arising from financial limitations may often have satisfactory temporary solutions when it is possible to develop the enterprise by stages. The extent to which this may be achieved will depend, amongst other things, on the market and production methods, especially as regards the indivisibility of the equipment. It is often possible to find a solution which, although not perfect, is at least acceptable, so that an enterprise can be developed gradually from the financial point of view, to avoid abandoning it at a given moment for lack of funds. If financial difficulties are foreseen, it is better to plan the construction by stages, so that each will give partial production, and can be integrated with later stages. By this means, if the foreseen limitations materialize, it will at least be possible to make use of such investments as have already been made. Not all projects have the elasticity to permit gradual development. Where they do have such elasticity combined with financial problems, the question of initial size is of secondary importance. Caution will generally advise the construction of the minimum size plant, expanding as operations reach a normal scale, and as financial resources become available.

### 6. *Other factors relating to size*

Finally, there is another factor which may at times have some effect on a project's size. Industries often operate with only one shift because of the lack of trained personnel, since entrepreneurs are loath to entrust valuable equipment to unskilled hands. This type of limitation will only affect unimportant projects, or very exceptional cases. In larger projects, the converse may arise, when consideration is given to problems of administrative capacity, central-

[8] Section II, 3 of this chapter.

ization or decentralization, which arise from operation at high production levels calling for considerable administrative experience and capacity in addition to technical personnel and skilled labour. As in the case of other factors, it may be preferable to begin on a smaller scale, where these problems will not have the same importance. Consideration of geographical decentralization and diversification, as well as of marketing problems, or merely caution, may lead to the installation of separate small enterprises when it would have been possible to centralize production in one single unit.

### 7. *Summary of the size problem*

The number of size alternatives is progressively reduced by the examination of engineering, investment, location and other questions affecting a project. The size of the market gives the first guide, since demand may be so low that only the smallest size is justified; any other solution is therefore out of the question. If the market is large enough to present various alternatives, many of them may be eliminated by the decisions on techniques and location. The remaining alternatives may be examined on the basis of the evaluation criteria mentioned earlier. The final decision could be adopted on the basis of these coefficients and of other factors which cannot be quantified.

Assuming that there were no factors limiting the size, and that the coefficients could be calculated for various production levels, it would be possible to draw curves showing the variation of these coefficients with the size of the project. It would still have to be decided if the optimum size would achieve the greatest profit, net return, the best sales-costs ratio, or the minimum unit production cost. To seek the answers to these questions, certain theoretical elements which affect these coefficients will be explained. Any exhaustive examination of these elements would require much greater detail, and would raise the argument to an academic level beyond the scope of this study. The brief examination which may be included might assist the planner, if in fact the degree of freedom assumed in the following analysis actually exists. It will be unusual in practice to elucidate the problem to any great length, either because these degrees of freedom do not exist, or because it is too expensive, or impossible, to complete all the necessary research.

Since the optimum size is a function of these coefficients, because of the variations of costs with size, that is to say, with economy scale, it must be previously decided if the size which will give minimum unit costs is the same as that which gives maximum profit, net return, or the maximum sales-costs ratio. Although in practice these differences may be obviated by the scales actually possible, and by other limiting factors, there is no such coincidence conceptually, except as regards unit cost and the sales-costs ratio. Assuming that the possible variations in the scale of the individual project will not affect the product's selling price, the size which will result in the minimum unit cost is the same as that which gives the maximum costs-sales ratio. It will be shown later that the scale which produces the maximum sales-costs ratio is not the same as that which gives the greatest absolute profit or net neturn.[9]

In view of these differences, a table may be prepared similar to that given below, showing the influence of the size of the project on unit cost, total profit and net return.

| *Size* | *Unit cost* | *Total profits* | *Net return* |
|---|---|---|---|
| I | | | |
| II | | | |
| III | | | |
| IV | | | |
| etc. | | | |

The values shown in the table can also be plotted on a graph, from which the most adequate scale may be deduced. If the optimum scale differs according to one coefficient, or another, the decision will depend on the point of view from which the problem is approached. The private entrepreneur is essentially interested in obtaining the maximum net return or total profits from his own capital;[10] unit costs interest him mainly in terms of his competitive position. From the point of view of the community as a whole, the basic interest is to produce goods or services at the lowest unit cost, and if the selling price is the same, the scale at which this is obtained is the same as that which gives the maximum sales-costs ratio.

[9] Section III of this chapter.

[10] The net return on equity capital is not necessarily the same as that of the total capital of the enterprise. See Part Two, chapter III.

## II. Location of the project

### 1. *Locational forces*

The selection of the suitable location for a new productive unit must be guided by the same objectives as the optimum size; the maximum profit rate, if it is a private investor, or the lowest unit cost if the problem is being considered from the social aspect.[11]

The location study consists of analysing the variables, which may be called locational forces, in order to determine the site where the resultant of these forces produces a maximum rate of profit or a minimum unit cost. For the purposes of the exposition, they will be examined separately, assuming in each case that the others remain neutral. The main elements to be considered are: (*a*) the sum of the transport costs of inputs or products, which must be minimum; (*b*) the availability and relative costs of resources; (*c*) the position as regards land and buildings, taxes and legal problems, general living conditions, climate, administrative facilities, centralization or decentralization policies, elimination of residual water, offensive odours or noises, etc.

Points (*a*) and (*b*) are usually the most important, and basically they are reduced to the one question of transport. Their separate treatment will nevertheless help to distinguish the substance of the problem. Point (*c*) covers a series of factors whose significance will depend upon the case in question.

[11] As in the case of the market, the unit cost may also be calculated on the basis of the "social cost" of the factors, if this differs greatly from the cost at market prices.

The factors affecting industrial location have been grouped in many other ways, although the conceptual basis remains the same. The United States Department of Commerce points out that the basic factors which normally govern the evaluation of factory sites are (*a*) location of the production materials; (*b*) labour; (*c*) available land; (*d*) industrial fuel; (*e*) transport facilities; (*f*) market; (*g*) distribution facilities; (*h*) power; (*i*) water; (*j*) living conditions; (*k*) laws and regulations; (*l*) taxation structure, and (*m*) climate.[12]

The problem is thus seen from the viewpoint of attraction of industry to specific areas. This is somewhat different from the aspect presented here, which is the location of a specific industry. Nevertheless, it is easy to see that within the three groups, the same thirteen factors appear as in the list given earlier. The reason for inclusion here is that it may be useful for a final comparison of the location selected in relation to each of these factors individually.[13]

The siting problem may be approached in two stages: firstly, the general area will be decided, and secondly the exact location, after examination of detailed problems such as cost of land, administrative facilities, etc. Some factors—taxation structure, legal concessions, availability of buildings, etc.—which are unimportant in some cases, are vital in others. These distinctions can only be seen when examining a specific problem. In general, the decisive problems will be transport and the availability and cost of input.

### 2. *Location and transport*

In some localities the sum of the transport costs of input to the plant and of output to the market will be small. Thus, series of geographical points can be established where freights are equally low. These points may be considered as possible sites for installing the industry, and, taking into account the remaining factors, it may be possible to select the final location from amongst them.

The analysis becomes more complicated when there are alternative input sources, or different geographical markets, or both. In these cases, there will be as many curves of minimum freight as there are combinations of markets and input sources. This complication also arises when different products are to be made, each of which satisfies a different geographical market.

In more simple terms, the problem resolves itself into one of knowing whether the industry is to remain close to the raw material and input sources in general, or close to the outlet market. Hence it is possible to speak of industries being "oriented towards the market" or "oriented towards inputs". (This naturally refers to those inputs of great economic importance.)

The weight of the raw materials may be greater or smaller than that of the finished product, which will give one clear indication as regards location. Thus, to make 100 kg of sulphuric acid, using sulphur as raw material, 32 kg of sulphur are needed;[14] if, in addition, the freight rates are higher for the acid, the industry should obviously be located closer to the market for the acid than to the sulphur mine. Conversely, if the weight of raw materials is greater than that of the product, the general trend would be to place the plant nearer to the raw materials (for instance, the iron and steel industry).

In the case of transport, it is not only the weight of the materials that is important but also volume and freight rates, since raw materials usually pay lower rates than finished products. The comparison must therefore include weight, distance and prevailing freight rates. No special problems arise in the calculations, since the project-engineering and analysis of derived demand will show the quantity, nature and source of the input materials, and the market study will indicate the quantities of finished products for sale in the various areas.

When it is obvious that the industry must be near to the raw materials, and more than one is used in large quantities, the problem arises as to which of these must travel the farthest. In the case of coal and iron ore for steel-making, the total weight of the raw materials is greater than that of the finished product, which means that the industry should be installed close to the materials. At the same time, the unit cost of transport and the weight of the ore may be approximately the same as those of the coal, and there is a problem as to location with respect to the two. The analysis will then be made on the basis of locational forces, including the future employment of the by-products. Coke, tar, gas, ammonia waters, raw material for slag cement, and benzene are all produced together with steel. The steel itself can be used to develop other industries: steel structures, nails and wire, ferro-alloys, castings in general, shipyards, etc. In an under-developed country, the iron and steel industry thus becomes the centre of a new industrial complex which may be programmed integrally. This programming would examine the location problem in a wider perspective than that limited only to the iron and steel industry. This example illustrates the complexity of the location problem. There are many important raw materials, and the two main ones normally have a very similar influence as regards physical weight; there are also a number of end products which lead to the opening of new markets. Therefore, when programming the industrial complex, not only must the market and transport relating to the actual steel industry be examined, but also the markets of the derived industries; plus other locational forces which will be mentioned later.

The importance of distances, volume and weight will depend on whether the transport of the iron ore and the coal or coke is easy or difficult. Thus, the scale of operation in the large industrial centres will often allow long hauls of raw materials from under-developed countries, at prices which may even be lower than those between two points in that same country.[15] It is basically a very special aspect of the tariff problem mentioned earlier.

### 3. *Availability and cost of input factors*

The availability and cost of the various factors in different geographical areas constitutes a locational force

[12] See "Basic Industrial Location Factors", *Industrial Series*, No. 74, June 1947.

[13] The difference between the problem of location in relation to an economic policy, and the same problem for a specific project should be emphasized. The first case is a problem for economic development programmes; it is the second which is discussed in these pages.

[14] A theoretical ratio has been taken in order to simplify the example.

[15] A United States steelworks imports iron ore from Chile, several thousands of miles distant, with special port installations, and ships specially designed for these installations. The scale of operation may be appreciated from the fact that the port in question, which is only used for the export of iron ore, has the gratest shipping volume of any Chilean port.

which again becomes a question of transport. Nevertheless, because of the peculiar nature of some inputs, and some industries, the problem presents special aspects which merit a separate examination. Under this heading, labour, some raw materials, electric power and fuel, and water will be discussed. In general terms, their influence will depend upon the quantitative effect on production costs.

(a) *Labour*

In technical literature, this aspect of location is often stressed, describing some industries as "oriented towards labour".

Industries employing high percentages of labour or manufacturing goods with high unit cost tend to be located close to centres where labour is in greater supply or cheaper. A typical case is the footwear industry.[16]

The estimate of this factor's effect on location must take into account the cost of labour in general, and the availability of specialized labour for the industry concerned. The problem will be closely related to the mobility of the labour force and the choice of location allowed the projected industry. The method of analysing the locational force of labour—assuming the remaining factors to be constant—will be as follows:

(*a*) To estimate the effect of the various types of labour required on the total production cost of the industry in question;

(*b*) To examine the availability of the various types of labour in the different locations;[17]

(*c*) To examine the rates of wages and salaries in the available locations;

(*d*) To estimate the effect of labour on the total production costs in the various locations, and decide if the differences are important or not.

(b) *Special raw materials*

Some raw materials are not easily transportable, either because of their physical properties or for other reasons. If these form a considerable part of the inputs, any possibility of transporting them over long distances must be discarded, and a location selected close to their point of origin. This may be the case for industries whose raw materials are perishable agricultural products or items which will not bear high freights (sugar beet, milk, wood, fruit for preserving, etc.). The same occurs when the basic material used in the project is, for instance, a poor quality fuel or a low grade ore.

An industry may often stimulate the production of certain goods; indeed, it may be located in a given area for precisely this reason. A typical case is the milk industry, which stimulates milk production because it is a stable consumer of this raw material. The same may occur with the conservation of fish, fruit and vegetables. The location problem is generally clearly linked in these cases to specific development programmes and policies.

(c) *Electric power*

In under-developed countries, the availability of electric power may be a decisive factor in the location of an industry, even though other factors point in another direction. The reason is that, although electric power can be transported over long distances, the investment required may be so large that in many cases it would be unjustified for a single industry. The cost of transporting the power may be prohibitive, so that charges are too high for certain industrial purposes. If there is no possibility of connexion to a grid, or if the rates are very high in a given area, a private generating station may be built or the industry may be sited close to a supply of cheap power. Since many other production facilities are often found close to the electric power supply (educational, health, administrative facilities, etc.), the balance generally inclines towards the latter decision.

In some activities (the electro-chemical industry, for instance), the availability of cheap electric power is essential. In others, the item is so small that its relative cost is of no importance. In this case, if no external sources of supply are available, a private plant is practicable, even if the cost is high.

A similar routine method may be followed as that already shown for labour, although an industry can always generate its own power, so that theoretically it is available everywhere.

(d) *Fuel*

Apart from its influence as an input, the technical alternatives for the use and transport of one or another type of fuel—coal, oil or gas—may also affect the selection of locality. Certain fuels may be controlled more readily in the manufacturing process (gas and oil). Some industries tend to use these more since the advantages of better technical control may compensate for higher direct cost. In other cases, the locational force of fuel may depend on its technical specifications as regards impurities, such as sulphur. Thus, one source may be preferable to another, because of its influence on the production processes. Finally, the ease of transport of the various types, depending upon whether they are solids, liquids or gases, will also affect costs, and the distance from their sources to the possible factory site. In short, the various sources of fuel may affect the location of the plant because of cost at the point of origin, technical characteristics and transport conditions.

(e) *Water*

Water is an almost indispensable input in all industries. It is needed both for a variety of individual human uses and for the population in general (orchards and gardens) and for many industrial purposes (boilers, cooling, and for the actual processes).[18] Its influence as a location factor is essentially one of availability. This influence will be lowest when there is water in the quantity and quality required in all the possible sites indicated by the remaining location forces. If water is available in some and not in others, this may become a factor of importance in determining the site.

[16] See Glenn E. McLaughlin and Stefan Robock, *Why industry moves South, A study of factors influencing the recent location of manufacturing plants in the South,* NPA Committee of the South, Kingsport, Tennessee, 1949.

[17] For example, in the areas of minimum freight examined in point 2 of this section.

[18] From the supply point of view, it is generally known that river water is usually higher in bacteria content, and less pure, but lower in minerals; well water is generally high in bicarbonate and carbonate, or in sulphate in some localities. In most cases, the latter is ideal for cooling, since it has a low and even temperature. There are naturally exceptions, one worthy of mention being that of a soda ash plant in a tropical country, where the alternative of sea water for cooling was adopted, in close relation to the location analysis of the plant.

Investigations into the availability and quantity of water may involve extensive work and investments, which at times may prove to be the key point of the project. Thus, for example, large mining developments are often projected for desert areas; in these cases, the location of the plant for processing the ore would be greatly influenced by water resources. The selection of location in a case of this type may require geological studies, well-drilling or civil engineering studies to determine some method of using more distant water.

### 4. *Other factors affecting location*

The third locational factor mentioned earlier[19] involves factors which are not normally decisive, but which may at times be of considerable importance. They are mentioned here, so that they may not be forgotten when making location studies; the order in which they appear below is not necessarily their order of importance.

(a) *Decentralization policy*

A deliberate policy of dispersal is sometimes adopted in order to reduce congestion in certain areas of a country. Under identical conditions, or even with slight disadvantages, industrial installations are encouraged in specific areas, usually with some taxation or similar incentive. At times, many projects are undertaken precisely with the object of taking advantage of natural resources known to exist in a certain area.

Certain administrative areas of a country—provinces, states, counties, boroughs, municipalities—sometimes frame their legal and taxations systems with the definite object of attracting enterprises. Because of the locational forces which they involve such stimuli may influence the siting of industries which can conveniently be dispersed geographically.

The intensity and effectiveness of these forces will vary greatly with the specific circumstances and nature of the stimuli offered. The influence of exemption from state or provincial taxation in Latin American countries is not likely to be great, because of the limited volume of taxes involved. If, on the other hand, the system of exemptions or special advantages in certain states becomes general throughout the entire country, these measures lose much of their attractiveness.

Credit policies may at times have a much greater effect, in view of the scarcity of long-term financial resources often encountered by the entrepreneur in under-developed countries. Bank investment credits, of adequate term, and at a low rate of interest, granted on condition that the enterprise is installed in a specific area, may become very effective locational forces.

Any means of encouragement must, of course, fit in with the remaining location criteria. Under equal conditions—or at least similar as regards the remaining factors—such stimuli may incline the balance in favour of a specific location, but in general it will not be sufficient in itself to govern the decision.

(b) *Administrative and housing facilities, etc.*

Some locations offer a number of facilities of this type, which may influence the decision. It must be understood

[19] See above (sub-section 1).

Table II

COMPARISON OF LOCATIONAL FORCES

| Possible locations | Annual freight costs | | | Unit costs of main items of input | | | | Unit cost of production and sales[a] | | Estimated volume of the market for the units produced | Estimated rate of increase of the market (annual)[b] | Recommended size | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Input | Output | Total | Labour | Raw materials | Power | Others | Production | Sales | | | Capacity | Cost per unit of installed capacity |
| A | | | | | | | | | | | | | |
| B | | | | | | | | | | | | | |
| C | | | | | | | | | | | | | |
| D | | | | | | | | | | | | | |

[a] The production cost is the cost in the factory; the sales cost includes all expenses up to delivery at the point of use (see chapter on budget of estimated expenditure and income).
[b] Other indications of the dynamic nature of the demand, if a uniform rate of increase is not foreseen.

clearly that these factors represent inputs into the industry, although often not forming a part of the explicit costs. In localities where such facilities do not exist, the industry must provide them to some degree, with the consequent additional investment and operating costs.

As part of the decentralization policy mentioned above, the provision of these facilities may be offered as an additional inducement. They thus become locational forces.

(c) *Living conditions and climate*

These may also become important in the selection of location, other factors being equal.

### 5. *Location in non-manufacturing projects*

The location problem has so far been examined only from the point of view of manufacturing projects, since, in other types, the problem either does not exist or is much less complicated. Projects for the extraction or production of raw materials or foods (mining, agriculture, fishing or forestry) must of necessity be executed in the place where the raw material to be extracted, or the resources to be worked, are found. If there are various alternatives, the most preferable will be that which shows the best economic evaluation. Similar criteria will be applied in the location of irrigation projects.

Electric power stations differ in their problems according to the type of installation. The location of hydroelectric projects for a specific river cannot be varied very greatly, and technical elements will have a strong influence on the determination of the most suitable point within the limited possibilities. In the case of thermal stations, the general location criteria will be similar to those for a manufacturing industry.

Location studies for transport projects present special characteristics, save in exceptional cases such as port installations, the construction of airports and terminal stations in general, when the location will be decided *a priori* by existing works, specific needs, or ports already constructed. From the point of view of a specific transport project—for example, a road from A to B—the "location" will be determined from the start, and the only alternatives will be the most convenient routes. In turn, the decision to build a new road from A to B will normally be related to a general transport programme of which it forms a part. The decision to establish a new route into a virgin or little known area also represents an *a priori* decision as regards location.

### 6. *Practical location problems*

As in the case of size, the abstract analysis of the location problem is of necessity more complicated than the study of a specific case for a given industry. The general theory of location of an economic activity must consider a series of factors as variables, which in the study of an individual project become inflexible.[20] Depending on the facts of the case, general policy or execution programmes, these cease to be unknown factors, and become data, thus simplifying the problem.[21] In specific cases, therefore, definite information will be available which will reduce the extent of operation to relatively close limits, obviating the necessity for extensive studies. The nature of the project itself will show whether the industry involved will be greatly influenced by its proximity to raw materials or the market, or by labour, power or other input problems. If it is normally oriented towards the market, and there are several geographical outlets, an important point will be the dynamic nature and the size of each. If the industry is oriented towards the raw materials, their various sources will be examined, first the heaviest or most bulky and then the others. This simple form of analysis will considerably reduce the number of alternative locations.

Once the problem is reduced to the choice between a limited number of alternatives, the relevant data can be presented in a form similar to table II.

Finally, these summaries of size and location may be combined and compared as to net return and unit cost, as shown in table III.

The presentation and study of the problem may be greatly simplified by the use of plans and diagrams. One could show, for instance, the sources of raw materials, possible electric power connexions, sources of water, market areas, distances by road and rail, etc. If there are competitive industries, their location and sources of supply can be shown, and curves of freight equality can be drawn.

In the actual project, it will be sufficient to give a summary of the most important conclusions reached as regards size and location, but it is advisable to include a special annex showing all the basic data employed, and the details of the analytical criteria used. These tables may show distances by road, rail or sea; freight tariffs; data on the sources of raw materials; etc.

In under-developed countries, the final location will often be decided whilst recognizing that many problems remain to be solved—repair of roads, improvement of railway equipment, extension of power lines, etc. The details of these points must appear in that part of the project which deals with organization and execution.

[20] For the general theory, see for example, Edgar M. Hoover, *The location of economic activity*, McGraw-Hill, New York, 1948; and August Lösch, *The economics of location*, Yale University Press, New Haven, 1954.

[21] For example, taxation or exemption in certain areas; concessions of land or natural resources; facilities for housing construction; government decisions to improve transport or install power stations, etc.

**Table III**

| Size | *A* | | *B* | | *C* | |
|---|---|---|---|---|---|---|
| | *Net return* | *Unit Cost* | *Net return* | *Unit Cost* | *Net return* | *Unit Cost* |
| I | | | | | | |
| II | | | | | | |
| III | | | | | | |

In these comments, the problem of optimum size will be examined from the standpoint of minimum production costs, profitability, the sales-costs ratio or modulus, and total profits.

### 1. *Sales-costs ratio and balance*

In technical literature optimum size is often discussed in the light of the relationship between what are called general benefits obtained from the projects and the costs. In the analysis of size, benefits are generally assumed to be the value of sales, although in a study of priorities, costs and benefits are often defined and evaluated in a social sense.[22]

If an estimate is available of the volume of costs and sales at different sizes, these values may be shown graphically as a sales-costs curve, with the sales as ordinates, and the costs and sizes as abscissae. Two important points can be determined from this curve: the maximum point of the sales-costs ratio, $\frac{S}{C}$ and the maximum point of difference between these two values, (S—C). An analysis of the curve will show that the scale of operation where $\frac{S}{C}$ is maximum will not be the same as for the maximum (S—C).

According to this criterion, the most appropriate scale for river basin projects will be somewhere between the scale where $\frac{S}{C}$ and (S—C) are at their maximum. If various projects are to be covered, or if the available funds are limited, then the scale of each project should be such that the marginal sales-costs ratio should be the same in all projects (ratios between sales and costs increments resulting from specific increases in the scale of production).[23]

### 2. *Minimum unit cost and the sales-costs ratio*

The scale of production which gives the minimum unit cost will be the same as that which shows a maximum sales-costs ratio, always assuming that the market selling prices do not change when the scale of production varies.[24] In fact, the ratio $R$ between the value of total sales and that of total costs will be equal, at any scale, to the ratio $r$ between unit price and unit cost. If the unit price is constant, the highest $r$ will be obtained for the minimum unit cost, and since $r$ and $R$ are equal, the scale of the project which will give a minimum unit cost will be the same as that which gives a maximum sales-costs ratio.

### 3. *Profit and net return*

If $K$ is the capital, will the same project produce maxima in both the expressions (S—C) and $(\frac{S\text{-}C}{K})$ ? There is no theoretical reason why this should occur, unless K remains constant; if this is assumed, then it must refer to an established enterprise, and the problem is to discover the maximum percentage of installed capacity which can favourably be used. Obviously, if the capital is the same, the scale of production which yields the greatest profit will be the same as that which gives the greatest net return. The problem here is to determine the production capacity which should be installed, that is, the alternatives with K as a variable. Therefore, there is no reason why the scale of the productive unit which will yield the absolute maximum profits should be that showing the greatest net return on capital.

### 4. *Sales-costs ratio and net returns*

Theoretically, the size which gives the highest sales-costs ratio is also the one which offers the greatest net return only when it is assumed that costs are proportionate to capital. Expressing profit by P and capital by K, a comparison will be attempted of the expressions $\frac{S}{C}$ and $\frac{P}{K}$. Since sales are equal to the sum of costs and profits:

$$\frac{S}{C} = \frac{C + P}{C} = 1 + \frac{P}{C}$$

If $C = rK$ (since $r$ is a ratio)

$$\frac{S}{C} = 1 + \frac{P}{rK} = 1 + \frac{1}{r}\frac{P}{K} = 1 + a\frac{P}{K} \ (\text{if } \frac{1}{r} = a)$$

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[22] The analysis of size as a function of the relationship between benefits and costs has been specially taken into account in the formulation of river basin projects in the United States, and has been adopted for the same purpose by the United Nations Economic Commission for Asia and the Far East. See, for example, (1) Economic Commission for Asia and the Far East, *Multiple-purpose River Basin Development*, Part 1, "Manual of River Basin Planning"; *Flood Control Series*, No. 7, United Nations publication, Sales No. 1955, II.F.1; (2) Subcommittee on Benefits and Costs, *Proposed Practices for Economic Analysis of River Basin Projects*, Report to the Federal Inter-Agency River Basin Committee, Washington, D. C., May 1950. The validity of the method for the private investor is analysed in the document published by the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, entitled *Water Resources and Economic Development of the West*, Berkeley, California, March 1953. See pp. 11 *et seq.*

[23] See Economic Commission for Asia and the Far East, *op. cit.* If investment costs can be distributed in this manner, maximum profits will again have been achieved for the whole group of projects. If $S$ is sales, and $C$ is costs, the optimum scale for each project would be obtained by prior determination of the scale which would give maximum (S/C), and increasing this size in the various projects until a distribution of funds is found where the ratios between increases in sales and increases in costs are the same in all projects. This argument assumes that the total costs at different scales are proportional to the corresponding investments; consequently, they are also proportional to investment increases. If this is so, an equal increase in investment between the various alternatives will mean the same increase in total production costs; if the corresponding increases in benefits differ between these alternatives, investments will be made where they will give greater unit profit. The funds would be distributed thus, until in any of the projects the marginal ratios were equal. As regards the practical application of this type of analysis, the publication of the Economic Commission for Asia and the Far East states that, in reality, solutions would never conform to the ideal, not only because knowledge is imperfect but because practical considerations of construction may rule out fine adjustments.

[24] A different hypothesis is advanced by the Economic Commission for Asia and the Far East in the study quoted earlier. There, it is maintained that, as more and more is produced, the additional output is used for less and less urgent purposes, thus causing a decrease in unit selling price. In the present analysis, it is assumed that variations in the scale of production of an individual project will not cause a general change in the unit price of the goods or services produced.

The expressions $\frac{P}{K}$ and $1 + a \frac{P}{K}$ will reach maximum at the same time, since $a$ is constant.

In practice, however, total costs and capital (for different sizes) will not generally be proportionate. Thus, doubling the capacity from 50 000 units per year to 100 000 units will not involve doubling the capital and each separate input item; in fact, these items will now be in different proportion. Thus $a$ will cease to be constant, and the scale which gives greatest net return may not be the same as another in which $\frac{S}{C}$ is maximum. It has already been shown that if the unit of the product price is maintained, the minimum unit cost will be attained with the same size as that giving a maximum for the ratio $\frac{S}{C}$. Therefore, the scale giving minimum cost need not necessarily coincide with the scale of maximum net return.

## Illustrative cases

### *Case 25*

### Size and location in a project for a beet-sugar mill

#### 1. *Approach*

This is a case of an industry which must be located close to its basic raw material, the sugar beet, which is not economically transportable over long distances.

The problem was approached by selecting a beet-growing area for the installation of the first plant. Agricultural research on the crop in various parts of the country, indicating possible beet-growing areas, was taken into account. The first task was to determine which of these areas was most suitable for the initial plant. At the same time, the question of size was considered, since the extent of the sugar beet crop in the district would also decide the capacity to be installed.[1]

To determine the size, maximum and minimum limits were established, based on European experience, which is that a daily capacity of 500 tons is small, whilst 2 000 tons is large. The maximum size is fixed by supply conditions; the industry works only during the harvest period (some 100 days each year).

The investment was not proportionate to the size. Equipment for a plant of 800 tons daily cost 2.7 million dollars, and for 1 600 tons, 3.5 millions. These data confirmed the need for installing the largest possible plant compatible with the supply conditions. It was concluded that a plant for 800 tons daily, designed with a view to doubling its output later, was the most suitable in view of expected supply conditions. It was hoped to reach the 800 tons output during the third year of operation. An industry producing less than 800 tons daily would cost very little less in equipment, and almost the same in installation costs; general production costs would be almost equal, so that the net return would be very much less. The 800-ton plant in normal operation—at full capacity—would give 10-per-cent net return, increasing to 18 per cent when the size was doubled.

#### 2. *Selection of beet-growing area*

The selection of the beet-growing area was based on the following considerations:

(*a*) Sufficient flat, irrigated land to supply a plant twice the size of that projected, if the whole area were used for rotated crops. The selected area covers 28 000 irrigated hectares; the total irrigated surface in the province, that is, the selected area and adjoining land, is some 70 000 hectares, to which irrigation works at present in progress will add another 20 000. The province would therefore have a flat, irrigated area of 90 000 hectares. For an annual production of 80 000 tons of sugar-beet, with an average yield of 30 tons per hectare—an estimate based on 5 years' experiments—2 600 hectares of beet would have to be sown, which, with a rotation of 1 in 5, would require a total available area of 13 000 irrigated hectares.

If the size of the plant were doubled, 5 200 hectares of beet would be required, and 26 000 hectares of land. Since there are 70 000 hectares in the province suitable for the crop (a figure which would later rise to 90 000), it was seen that even with longer rotation periods, and some sectors not growing beet, there would be a sufficient safety margin to supply a plant twice the size of that projected. In other words, the selected size was compatible with the available natural resources within the factory's zone of influence, and the real problem was to introduce the crop on an industrial scale. This aspect formed an agricultural project, parallel with the industrial one.

(*b*) Mechanization would be no problem in these flat lands; in this respect, they had an advantage over more hilly territory.

(*c*) It was not expected to obtain the whole supply from any one district during the first years. It would therefore be necessary to bring the beet from more distant areas, even though freight costs would thus be higher; for this reason, the factory was to be sited so as to utilize more distant crops. These possibilities would be lost by locating the plant elsewhere, since the distance would be much greater.

(*d*) The agricultural yield was greater in the selected district during the experimental stage.

(*e*) Beet-growing must always be close to livestock farms, and it is precisely this combination which gives a better agricultural production. In the selected area, dairy farming is well-developed. Three plants already engaged in dairy production output would form an immediate market for the expected increase in milk output.

(*f*) Agricultural studies in the area showed that it would be possible to obtain labour. The mechanization of wheat-growing, and other types of crop-farming included in the parallel agricultural project, would free a large proportion of workers, who would be available for the intensive cultivation of beet. Furthermore, the beet-growing operations which require a heavy labour input—thinning and harvest—are carried out at times of the year when the manpower needs of other farm sectors are lowest.

(*g*) There is no market problem. In the proposed location, the plant will be close to large purchasing centres; this will also reduce freight costs.

[1] Demand in this case did not constitute a problem, since it was an import substitution industry, and its maximum capacity would not exceed 10 per cent of the existing market.

**Table 60**

CASE 25. COMPARISON OF LOCATIONS FOR A BEET-SUGAR MILL

| | *Location A* | *Location B* |
|---|---|---|
| Fresh water | — | X |
| Residual water | X | — |
| Labour | — | X |
| Housing | — | X |
| Roads | — | X |
| Land | X | — |
| Electrical connexion | — | X |
| Administrative facilities | — | X |
| Railway situation | X | — |

(*h*) Other important raw materials are coal, limestone and coke. The largest coal mines in the country are close to the proposed location; coke and limestone will be purchased from an iron and steel plant in the same area, which gives further advantages over other locations.

(*i*) Comparing transport conditions with other possible areas, the selected district is again the most favourable, since it is more compact, and has an acceptable road network which will not be expensive to maintain.

### 3. *Siting*

Having selected the beet-growing area, the precise site was discussed. The problem was finally reduced to two alternatives, linked to the only railway in the area. These two possibilities were first compared for the following points: fresh water, disposal of residual water, labour, housing, roads, land, electrical and rail connexions, and administrative facilities. None of these factors presented substantial differences, so no attempt was made to quantify them.

Once the various factors had been analysed, Table 60 showing the more favourable location for each was prepared. Since there was no great difference, it was assumed that they all carried the same weight, so new factors were added, which gave location B six advantages.

The freight problem was examined next, including all products brought into or sent out of the plant. Incoming freights gave the following figures, expressed in monetary units per ton of beet:

| | *Location A* | *Location B* |
|---|---|---|
| Sugar beet | 41.80 | 31.50 |
| Other materials | 22.44 | 23.40 |
| Total | 63.24 | 54.90 |

The difference in favour of B represents a reduction of 0.5 per cent in total production costs. Outgoing freights produced no appreciable difference between the two locations, although B again had a very slight advantage. Finally, the expansion factor was considered, and the areas where increased beet production was planned to supply the plant once more favoured location B.

## *Case 26*

### Analysis of capacity to be installed in the case of a copper smelter

The following example was taken from a preliminary study to decide on the advisability of installing a second copper smelter in Chile, to process ore from the so-called small and medium mines.[2]

### 1. *Approach*

The study in question[3] tended to justify the installation of a new smelter, and established the technical and commercial bases of tenders for the study, supply of equipment and machinery, and technical supervision of the installation of the industry.[4]

The problem of size was not presented in this case from the demand angle, but rather from that of the demand for ore which must supply the smelter as a result of the project. It is not an attempt to place additional copper on the market, but to process in the country ore which was formerly exported either directly or after mechanical concentration. On the other hand, the increased copper production which would be stimulated by the new smelter would be entirely insignificant compared to the world copper market. Although there were no marketing problems, the size of the new smelter raised questions of supply. Since it is intended to process ore from many widely separated mines, the study of the melting capacity had to take into account possible variations in both tonnage and mineralogical composition of the production. The author of the project based his argument on the fact that, at lower ore prices, the mines with high production costs would become marginal, and there would be a reduction in tonnage; as evidence of this he quoted his own analysis of historical series.[5] During periods when, for various reasons, prices declined, or costs were high, there was a trend towards reduced output of direct-melting ores, which always had a high production cost. Mechanized concentration plants could withstand the conditions better, but they also had difficulties. If the smelter were to depend on a single mine it would be simple to establish the break-even formula, in relation to the price of copper and production costs. In the case of a custom smelter, however, serving an area ranging from Ovalle to Rancagua,[6] with different mines and plants, there were many independent variables which made it impossible to estimate the break-even points.

He considered that if the projected smelter were to be capable of adapting itself to those variables, its capacity should not be rigidly laid down. It would, in fact, be better to provide the maximum possible flexibility, starting from the minimum for economic operation, but with sufficient elasticity to meet the needs of increased production within its zone of influence. On that basis, the minimum capacity of technically and economically practicable smelter should be calculated.

### 2. *Minimum capacity*

Because of the types of ores and fuels, the reverberatory furnace was taken as the most suitable, and the conversion

[2] The small and medium mines in Chile comprise a number of small-production units, as distinct from the there large mines. Each of them justifies installations for processing the ore to the metallic copper stage. They generally export crude copper (export or direct-melting ores) or ship ores to concentrating plants (ore concentrates). The medium mines have their own concentrating plants, and have therefore a more stable production.

[3] Julio Dominguez M., metallurgical consultant to the "Empresa Nacional de Fundiciones", *Estudio comparativo para establecer una fundición de cobre en el centro de Chile*, Santiago de Chile, 1955.

[4] For the bids, see case 2, annex III, and case 2, annex V.

[5] He referred here to a chapter in his study specially devoted to historical production series for various types of ore, over the whole country.

[6] These towns are some 500 kilometres apart.

**Table 61**

CASE 26. ANNUAL ESTIMATES OF ORE AVAILABLE FOR THE NATIONAL SMELTERS

*(Tons)*

| *Type of ore* | *Present smelter* | *Projected smelter* | *Total* |
|---|---|---|---|
| Copper concentrates | 45 000 | 55 000 | 100 000 |
| Copper and combined ores | 65 000 | 20 000 | 85 000 |
| Gold and combined ores | 2 000 | 1 000 | 3 000 |
| Total ores | 112 000 | 76 000 | 188 000 |
| Lime fluxes | 23 000 | 15 000 | 38 000 |
| Silicon fluxes | 8 000 | 6 000 | 14 000 |
| Total fluxes | 31 000 | 21 000 | 52 000 |
| Total melt | 143 000 | 97 000 | 240 000 |
| Copper content | 17 000 | 14 000 | 31 000 |
| Gold content kg. | 700 | 300 | 1 000 |
| Silver content kg. | 7 000 | 3 000 | 10 000 |

of blister copper must be made from easily converted mattes, that is, between 35 and 45 per cent copper.[7]

If a reverberatory furnace is to maintain its thermal coefficient, with perfect combustion, it must not be less than 70 feet long nor 20 feet wide; the working area is thus 1 400 square feet. Assuming an effective, fresh charging coefficient of 140 kilogrammes per square foot, this area would provide a daily capacity of 196 tons (6 000 tons monthly); if this capacity is reduced by 20 per cent to allow for lime and silicon fluxes, the useful ore capacity is reduced by 4 800 tons monthly, giving a minimum annual charge of 57 000 tons.[8]

On the basis of ore production statistics, the author of the project estimates that this minimum figure will easily be surpassed. Further, he sustains that production in the smelter's zone of influence would only fall to this level during "periods of crisis", when the production of ore for direct sale becomes uneconomic for many mines, and the production of concentrates only would continue as a basis.

Table 61 shows what would be the normal availability of ore in the whole country, assuming the maintenance of prices and general economic conditions of 1954, the year when the study was made. Since one smelter already exists, a column is added to the table showing the smelter's requirements, and the surplus left for the projected smelter.

The project-maker points out that the estimate in Table 61 should not be taken as a firm value. He recalls that these were figures calculated on the basis of a relatively high copper price—around 30 cents per pound—and rather low costs resulting from the exchange rate.[9]

Some 76 000 tons would be available for the new smelter, against a minimum capacity of 57 000. Normal production would therefore have to fall by 20 per cent to reach the smelter's minimum requirement. In this case, as mentioned earlier, the material for smelting would be mainly concentrates from the more economically stable mines. Direct-melting ores would only be added to the concentrates in sufficient proportion to produce a "workable slag".[10] It is estimated that these would be 20 per cent of the total charge, whose monthly composition would be as shown in Table 62.

With 96 per cent recovery, the production of blister copper would be 950 tons; the matte would be 35 per cent copper.

These calculations allowed the project-maker to determine the size of the converters, which convert the matte (35 per cent copper in this case) into blister copper. For a daily production of 32 tons of blister copper, using 35 per cent copper matte, a converter of 13 by 10 feet would be required, with 4 melts daily, of 7 500 tons each. Hence, two of these converters would be required for the project.

The above figures would represent the maximum production of the smelter-converter unit, with the assumed minimum capacity. If the production of concentrates is increased, or if their copper-sulphur ratio produces a matte with less than 35 per cent copper, a roaster with 25 tons daily capacity would also be required.[11]

The analysis of minimum capacity concludes with the statement that a smelter of this type would consume 960

[7] The technical process comprises two basic stages: (*a*) smelting the ores and concentrates in a reverberatory furnace to obtain copper "matte"; (*b*) processing of the matte in converters to obtain blister copper, which is almost pure (98-99 per cent).

[8] When calculating the coefficient per square foot, the non-working periods (for repairs) have been considered. The fluxes mentioned are needed to assist the melting process and the formation of the matte.

[9] Copper later rose to 50 cents per pound (1955), decreasing again in mid-1956. Statistical studies show that when the copper ore output rises as a result of high prices, that of gold decreases, and vice versa; in general, therefore, the total tonnage tends to remain constant.

[10] The mineralogical and chemical composition of the furnace charge is decided in such a way that a good separation is obtained between a predetermined grade of matte and the slag.

[11] Roasting eliminates part of the sulphur before charging into the furnace, thus giving a higher grade matte. The sulphurous gases can be utilized to make suphuric acid.

**Table 62**

CASE 26. MONTHLY COMPOSITION OF THE FURNACE-CHARGE WITH MINIMUM CAPACITY

| | *Tons* | *Copper grade (percentages)* | *Refiner copper (tons)* |
|---|---|---|---|
| Concentrates | 3 500 | 25 | 875 |
| Ores | 1 200 | 8 | 96 |
| Lime flux | 900 | 1 | 9 |
| Silicon flux | 400 | 3 | 12 |
| Total | 6 000 | 16.5 | 992 |

tons of petroleum monthly, and, assuming a boiler heat recovery coefficient of 35 per cent of the total fuel, it may be estimated that at least 800 HP in electrical energy would be produced by the boilers, which would be sufficient for the plant's needs. The precise calculation would be made on the basis of the final design, specifying the type of boilers, distance from the furnace, steam pressure, and other technical factors. The author of the project did not see any useful purpose in making an analysis of all machines and auxiliary apparatus needed for a smelter of the assumed minimum capacity. His study was concerned only with the general layout of the plant, and expansion possibilities, in order to determine estimated costs of the unit.

On the basis of these ideas, the possibilities inherent in the plant may now be examined.

### 3. *Maximum capacity*

The author of the project had already shown that the present production of the central zone, where the smelter would be located, amounted to nearly 50 000 tons of concentrates annually; because of certain projects already under way, and the maintenance of existing market conditions, that figure might be expected to rise to 100 000 tons, especially in view of the existence of a near-by smelter. The output of unconcentrated ores with more than 6 per cent copper, from within the zone of influence, also had to be considered, in addition to goldbearing ores which would enter into the production. Although available data made estimates somewhat speculative, it would not be too rash to assume that, if the zone were well-developed, it could supply more than 40 000 tons of direct-melting copper and gold ores under favourable market conditions. Assuming that flux consumption would remain at 20 per cent of the total charge, the figures in table 63 would probably indicate the upper capacity limit of the projected smelter.

**Table 63**

CASE 26. UPPER LIMIT OF SUPPLY

| | *Tons* | *Copper grade (percentages)* | *Refined copper (tons)* |
|---|---|---|---|
| Concentrates | 100 000 | 25 | 25 000 |
| Ores | 40 000 | 8 | 3 600 |
| Fluxes | 35 000 | 2 | 700 |
| Total | 175 000 | 17 | 29 300 |

Blister copper: 28 100 tons annually, matte grade 31 per cent.

The conversion of a matte with such a low copper content would not be economic, and 15 000 tons of concentrates would have to be roasted. A 50 000-ton furnace would thus be required to produce a matte of more than 40-per-cent copper and also three converters each of 30 tons daily. This installation would also have to include a holding furnace and a barmoulding machine.

To embrace all possibilities, it must be accepted that the maximum figures given above may be exceeded, and that the smelter must be planned to absorb an increase greater than that calculated. This does not mean that a plant must be planned which could accept a high tonnage from the first, but only that it must envisage the possibility of processing up to a maximum of 200 000 tons annually, as shown below:

| | *Tons* | *Refined copper (tons)* |
|---|---|---|
| Concentrates | 125 000 | 31 250 |
| Ores | 50 000 | 4 000 |
| Fluxes | 45 000 | 900 |
| TOTAL | 220 000 | 36 150 |

This smelter could process 10 000 tons of fresh charge monthly, and produce 3 000 tons of blister copper.[12]

### *Case 27*

RELATIONSHIP BETWEEN SIZE AND COSTS IN THE IRON AND STEEL INDUSTRY

The following example is taken from *A study of the iron and steel industry in Latin America,* by the United Nations Technical Assistance Administration and ECLA.[13] Only two tables have been used from that study, which show the influence of size and location on the final figures. These summarized tables are sufficient for a simple illustration; if the reader is interested in greater detail, he may consult the study quoted.

The first of these (table 64) emphasizes the influence of size on production costs for a given location (in this case, Sparrows Point, United States). The second (table 65) shows costs for different locations in Latin America and for two sizes in each location—one according to the existing market, and the other for 250 000 tons. This

[12] See case B (chapter III), for the manner in which these flexible conditions were included in the request for tenders.

[13] E/CN.12/293/Rev.1. United Nations publication, Sales No.: 1954.II.G.3, vol. I.

**Table 64**

CASE 27. ESTIMATED PRODUCTION COSTS AT DIFFERENT CAPACITIES IN AN ARBITRARY LOCATION

*(Dollars per ton at 1948 prices)*

| | *Annual capacity in tons of rolled steel* | | | |
|---|---|---|---|---|
| | *50 000* | *250 000* | *500 000* | *1 000 000* |
| Pig iron | 53.32 | 36.49 | 33.65 | 27.63 |
| Steel ingots | 76.99 | 53.25 | 47.42 | 40.02 |
| Rolled steel | 155.66 | 100.93 | 83.79 | 71.92 |

*Source:* E/CN.12/293/Rev.1. *op cit.,* totals of tables 35, 36 and 37.

Table 65

CASE 27. DIFFERENCES BETWEEN PRODUCTION COSTS FOR FINISHED STEEL IN PLANTS, ACCORDING TO SIZE

| Location | Cost per ton[a] (Dollars at 1948 prices) | | | |
|---|---|---|---|---|
| | *Annual capacity (Thousands of tons)* (A) | *In plants adjusted to size*[b] (B) | *In 250 000 ton plants* (C) | *Percentage difference* $\frac{B-C}{C}$[c] (D) |
| Chimbote (Peru) . . . . . . . | 50 | 102.22 | 80.20 | +28 |
| Chimbote (Peru) . . . . . . . | 150 | 88.29 | 80.20 | +10 |
| Barcelona (Venezuela) . . . . . | 200 | 106.60 | 98.78 | + 8 |
| Huachipato (Chile) . . . . . . | 230 | 82.44 | 81.14 | + 2 |
| Belencito (Colombia) . . . . . | 250 | 75.98 | 75.59 | — |
| Barcelona (Venezuela) . . . . . | 300 | 93.65 | 98.78 | − 5 |
| Monclova (Mexico) . . . . . . | 430 | 83.10 | 89.91 | − 8 |
| Volta Redonda (Brazil) . . . . | 716 | 85.41 | 95.74 | −11 |
| San Nicolas (Argentina) . . . . | 850 | 91.66 | 102.47 | −11 |
| Sparrows Point (United States) . | 1 000 | 71.92 | 94.67 | −24 |

*Source*: E/CN.12/293/Rev. 1. *op. cit.*, table 44.
[a] Size equal to the existing market in the country given in A.

table illustrates the influence of both the scale of operation and location.

Plant size has the greatest influence on costs: the lower the scale of operation, the higher the cost and investment per unit of production, and the less the productivity. Between 4 and 6 tons of raw materials are required to make 1 ton of pig iron, depending on the grade of ore and the purity of the coal. Transport of these materials therefore constitutes an important item in total production costs, and this, together with the freights of finished products to the market, determine the most economic location for the plant. In some countries of the region—specially Brazil, Colombia and Mexico—the distances are great, transport is difficult, and the consumer areas are relatively scattered. As a result, demand has been met from more than one steel plant, even though each of them had to operate on a small scale. Even if the demand were met entirely from one plant, however, the optimum productivity of the more industrialized countries could not be achieved.

In other words, Latin America is faced with the special problem of discovering iron and steel processes which allow better productivity in smaller scale operations. Orthodox procedures in small-market countries would lead to excessive operating costs.

Table 64 demonstrates that, above 250 000 tons annual capacity, the reduction in costs is less steep, and that capacity was adopted in the study for this reason.

The simultaneous influence of location and size on relative costs may be seen from table 65.

### *Case 28*

### Supply of raw materials and location in a soda ash plant project

In this project, the problem of ensuring the availability of raw materials was analysed in close relation to the question of siting and the technical production alternatives, since it was possible to choose between sources of raw materials with different characteristics. The decision on location therefore determined not only the site itself, but also certain technical aspects of the project.

Salt and lime are the two basic raw materials for a soda ash plant. In the case of this project, the alternatives of obtaining the salt from a mine or from sea water were studied. The mine was discarded, in spite of the better quality raw material, because of plant location and freight considerations. The decision to use sea water as a source of salt supply was based on careful study and research. The salt from sea water salines is obtained in crystallized form, and is later dissolved in fresh water free from magnesium, sulphate or other impurities normally found in sea salt.

The extraction of sea salt involves an evaporation process. Observations were made over a period of one and a half years at various points on the coast, seeking data on atmospheric pressure, air temperature and humidity, precipitation and evaporation. The object was to establish correlations between these data and meteorological observations covering longer time-series, in order to extrapolate backwards. Experimental evaporators, one metre square, were constructed and exposed to direct atmospheric action, and also an experimental salt pan.

These studies indicated the area of the pans required to supply the industry. The meteorological data showed that evaporation and rain periods are short, which would frequently interrupt the evaporation and crystallization process. By reducing the evaporation time to that required to obtain a concentration of 25° Beaumé, it was possible to make much better use of the water conditions. With this concentration, the solutions would pass to covered pans where concentration and crystallization would be completed in a vacuum.

There are definite chemical impurity tolerances for calcareous raw materials used in soda-making, and they must also have a certain physical resistance in the kiln. An undersea deposit of sea-shells was discovered near to the proposed location, and its extent was determined by a series of dragging operations every 500 metres of a squared grid. The shell was extracted mixed with sand, and a test installation was set up to study the methods of separation by fresh water washing and rotating screens. A drag scraper was used in these operations, which provided the following data: confirmation of the extent of the deposit, most suitable types of screen and drag, conditions for washing the silicon clay and silicon-clay mixture, chemical composition of the lime from larger samples, and estimate of the production cost. The results indicated a sufficient volume and a favourable cost.

Industrial water in this case has three basic uses for the process itself, domestic and irrigation purposes, and cooling. The first two uses involve fresh water, but sea water can be employed for cooling. It was estimated that 8 million litres of fresh water would be required daily for an annual production of 100 000 tons of soda ash. This water would be used for brine-making, various factory purposes, general services, and the second washing of the lime and boilers. The fresh water would be treated, to comply with technical requirements.

Under the local conditions, household consumption by each of the 6 000 persons to be employed by the projected industry was estimated at 250 litres daily. The total daily volume of fresh water was estimated at 9.5 million litres.

After a number of experiments to discover the best temperature, it was decided to use sea water for cooling. The experimental period covered 17 months of daily observations before a suitable point was found.

## Chapter V

# INVESTMENTS IN THE PROJECT

### I. General concepts

The decision to proceed with a project requires the allocation of a quantity of various resources, which may be grouped under two headings: (*a*) those required for the installation of the project, that is, the assembly of what is known in the definition of projects as the "centre of transformation" of inputs, and (*b*) those required for the actual operation of the project.

The resources needed for the installation are the fixed capital, and those for operation, the working capital. The reduction of the value of these resources to monetary terms involves the problem of deciding the prices to be used in the calculation, which may be either the market prices or the social costs of the various factors.

[1] Social costs are the market prices corrected in accordance with the social criteria explained in Part Two.

The following pages will deal with investment from the financial point of view, that is to say, valued at market prices and including all payments made, whether for transfers of assets or not.[2] The volume of the "investment" calculated in this manner will give essential information from the point of view of practical development and the financial mechanics of the project. It will also form the basis for calculating the volume of the "social investment".

Firstly, the single-purpose project will be dealt with and later the problem of allocating investment costs in multi-purpose projects.

[2] Within investment values at market prices, an additional distinction must be made between items which represent new contributions and those which only involve transfer payments. Thus, for example, the purchase of land for the installation of a factory or for an agricultural project does not create new assets for the community; there is only a change of ownership of the assets.

### II. Investment calculations in single-purpose projects

#### 1. *Fixed assets*

Fixed assets are those goods which are not involved in any of the enterprise's normal transactions. They are acquired once only during the installation of the project, and are used throughout its useful life.[3] Their monetary value constitutes the fixed capital of the enterprise. Physical assets can be divided into those which are subject to depreciation and obsolescence or wear (for example, machinery, buildings) and those which are not (for instance, land).

In the case of agricultural projects it is accepted that the land, which forms a large part of the fixed assets, does not depreciate, and normal working expenses include those necessary for conserving the land's fertility and productive capacity.

Fixed assets are often divided into tangible and intangible assets. The tangible fixed assets are the machinery and equipment plus installation costs, buildings and auxiliary installations, land and natural resources (mining property, forests and plantations, etc.). Typical intangible assets are patents, copyrights, expenses involved in the organization and running in of enterprises, and others. Some of these assets—for instance, patents and organization expenses—are amortized over conventional periods. From the project angle, the main difference lies in the depreciation or amortization periods for each type of asset.

The calculation of fixed capital must include essentially the following points: (*a*) specification and determination of the components of the investment in physical terms (buildings, machinery, labour, etc.);[4] (*b*) valuation of these components at market prices, i.e., estimation of the prices which should be paid for them according to their true market quotation at the moment of purchase; (*c*) determination of the project's renewable contribution to tangible national assets, and (*d*) compiling of the data needed to estimate the volume of investment in terms of social costs.[5]

[3] The calculation of depreciation and obsolescence is dealt with in chapter VI of this First Part. See specially section II, 7.

#### 2. *Items of fixed investment*

The relative volume and the nature of the items comprising the investment will vary considerably with the different types of projects, and, as explained earlier, will be defined in the technical phase of the study. In general, they will be the following: (*a*) costs of research, experiments and preliminary studies; (*b*) cost of land for the installation; (*c*) cost of natural resources (mineral deposits, forests, or others); (*d*) cost of equipment; (*e*) installation costs of the equipment; (*f*) cost of industrial buildings; (*g*) cost of auxiliary installations;[6] (*h*) cost of the project study; (*i*) cost of organization of the enterprise; (*j*) cost of patents and similar expenses; (*k*) engineering and administrative costs during installation and construction; (*l*) expenses of running-in period; (*m*) interest during installation and construction; (*n*) pre-

[4] These components will be defined in the engineering study.

[5] The type of information required for this purpose will be explained with reference to evaluation problems; it will mainly be concerned with customs duties and other direct taxes on items which form part of the investment, exchange rates, origin of the labour force, and others.

[6] See chapter III, section II, 6.

paratory installation work; (*o*) unforeseen contingencies.

These items will be described briefly below, associated items being considered jointly.

### (a) *Preliminary research and costs of the project study*

These items are not always included in the cost of the project. For instance, at times the research, preliminary experiments and the general study of the project have been entrusted to a development institution, or have been undertaken directly by the State through research centres. The outlay may be charged to non-recoverable development expenses, and the results of the research may be given free of cost to the public or private enterprise which will execute the project. If existing enterprises are widening their field of action, the outlay on research and studies is charged directly to the respective projects.

It is usually difficult to draw a clear dividing line between these different procedures. In mining projects, considerable expense may be involved in research and drilling; this will most probably be charged to the investment, in the cases of both the public and private sectors.[7] On the other hand, costs incurred by experimental State agricultural establishments in the development of new rotation practices, or new types of cultivation, are not charged to the agricultural project or projects which make use of them. Similar considerations arise with regard to the costs of the actual project study. Thus, in practice, the criterion is completely conventional, even when the project should be charged with the costs of all resources employed, including the preliminary research stage.

### (b) *Equipment, buildings and complementary installations*

The cost of the equipment and its installation, and of the buildings and auxiliary installations are calculated from quotations received, based on engineering specifications. Imported items will be detailed at prices F.O.B., C.I.F. and placed on site. In most cases, the installation costs will include the payment of skilled foreign personnel. This is advisable firstly, because of their experience, and, secondly, because suppliers often guarantee their equipment only if it has been installed by their own personnel, or by duly authorized technicians.

The equipment used during the installation must also be taken into account; this will often have other uses after completion of its original task. In such cases, only the depreciation or hire costs of the equipment will be included.

### (c) *Organization, patents and similar problems*

The execution of a project normally includes the organization of a special enterprise, except when it consists only of additional installations in an existing one. Even in the latter case, the project may bring to light problems of expansion or administrative reorganization which involve expenses chargeable to the investment. Legal and tax expenses arising from the formation of the enterprise are also included in this item.[8]

The general criterion is to consider the expenses of "organization of the enterprise" as part of the intangible assets, amortizing them over a relatively short period. Patents, copyrights and similar expenses are considered according to the manner in which they are incurred. If a payment is to be made according to the number of units produced,[9] it will come under operating expenses, but if paid only once, at the beginning, it is part of the investment, subject to depreciation and obsolescence.

### (d) *Land and natural resources*

Land and natural resources are normally part of the financial investment, but not in the sense of capital formation, since the payment made for the right to use these resources does not imply the formation of savings, and does not represent a contribution to renewable assets. The costs incurred in determining these resources have been included in the item "studies and preliminary research".

### (e) *Engineering and administration costs*

The engineering and administration costs during assembly and installation include the salaries of the technical and administrative personnel involved in directing and organizing the complete operation. They may be estimated by itemizing all factors constituting a particular case, or by means of an over-all percentage of the total investment in the case of a less precise estimate.

### (f) *Expenses of running-in period*

The costs of running-in are the disbursements or operating losses incurred in testing the installation, and setting it in operation, up to the stage where it is functioning satisfactorily. This is a characteristic of manufacturing enterprises, but it may also be of considerable importance in other types of projects, as previously explained.[10]

These costs must be imputed to the fixed investment, and amortized over a conventional period, which sometimes is reduced to two years. The important point to remember is that financial resources must be available to cover this period, and a separate item must be included in the investment calculation for this purpose. The amount involved may be estimated from experience with other similar projects already in operation.

### (g) *Interest during the construction period*

During the assembly stage, the invested capital produces no income, but if it were placed elsewhere, it would be earning. The investment must therefore include the value of the interest which the capital would have earned up to the time of entry into operation, that is, until the investment commences to produce.

When the investment is made with private capital, this interest does not constitute an actual disbursement, and the item becomes one for evaluation. If, on the other hand, financing is by means of credits, there will be an accountable sum involved in this interest. If, for example, an investment credit is obtained with the stipulation that the service of the debts will begin once the project is started, the interest on the credit during the assembly

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[7] State mining services and research institutes often provide very useful geological and metallurgical studies, free, as part of the development of national resources.

[8] Even when the formation taxes and legal expenses constitute items with special characteristics, the fact that they are small in relation to the total investment is no justification for considering them separately.

[9] For example, "royalties".

[10] See also point 9, referring to working programmes, section II, chapter III, Part One.

Table IV

INTEREST ADDED TO THE EQUIPMENT INVESTMENT DURING THE CONSTRUCTION PERIOD

*(4 per cent annually)*

| *Payment to suppliers according to the equipment delivery contract*[a] | *Time interval up to beginning of interest payments (Months)* | *Total percentage to be applied* | *Amounts to be added to the investment*[a] |
|---|---|---|---|
| 100 | 36 | 12 | 12 |
| 200 | 24 | 8 | 16 |
| 50 | 12 | 4 | 2 |
| 50 | 6 | 2 | 1 |
| 400 | | | 31 |

[a] In hypothetical monetary units.

stage will be charged to the loan, and the total debt will be the value of the credit plus interest accruing during the assembly period. This interest is not merely an imputable sum, but must be actually paid out. Supposing that the credit is for the purchase of equipment and amounts to 400 monetary units, which, according to the contract with the suppliers, is to be used in four quotas, corresponding to the delivery dates of the equipment. Assuming 4-per-cent interest, the financial calculations will be as shown in table IV.

When production starts, the total debt is 431, which is the amount of the investment in this item. The interest on the total debt will be charged in turn to the cost of the financial operation.

It is advisable to establish clearly the difference between interests charged to the investment during the construction period and those arising from the operation, once the enterprise is functioning. The former are part of the investment, and the second comprise direct production costs and are paid year by year as all other production costs.

### (h) *Preparatory installations*

This item covers the resources needed for the temporary installations which must be set up before work is started. Included here are workers' camps, stores and temporary offices, and in general, all installations to be used during the preliminary stage, before completion of the final buildings. As the latter are completed, they may be used for the assembly stage (for example, workshops, workers' houses, etc.). If the site is distant from any populated area, the preparatory installations may involve substantial sums.

Part of the cost of these installations can often be recovered, either because they can be used again, or because they have some residual value.

### (i) *Unforeseen and miscellaneous contingencies*

Items of lesser importance are grouped here (fire insurance or others concerning only the assembly period), and an over-all sum to cover contingencies not foreseen in the study (for instance 10 per cent of all the above items). The inclusion of this item is an acknowledgement of the practical limitations involved in budgeting investments with mathematical precision. The percentage to be allowed is entirely arbitrary, and will depend on the precision with which the partial items have been prepared, on the degree of uncertainty regarding the immediate future, on the ease or difficulty in obtaining additional funds if the estimate proves to be low, and especially, on the experience and foresight of the planners.

## 3. *Working capital*

Working capital is the capital in current account which enterprises require for the production or distribution, or both, of goods or services.

In the case of a manufacturing industry, it is not sufficient to possess equipment and installations in order to produce; a supply of raw materials, spares and miscellaneous materials must be maintained in store; there are goods in course of manufacture, and finished products in stock, goods in transit, and accounts receivable. In the case of agriculture, resources must be on hand between harvests for the farmer's subsistence as well as for buying seeds and fertilizers and meeting other costs of cultivation. Such resources constitute the farmer's working capital. They are quite distinct from fixed capital assets; they are therefore referred to as current account goods, as opposed to capital goods.

The precise limits of the concept vary according to the object of the analysis in which it will be used. Working capital really includes all assets of the enterprise in current account, i.e., general inventory of raw materials, fuels, etc., finished or semi-finished products, accounts receivable, advances to suppliers, cash in hand and in banks, and so on. Bankers, accountants and private investors, on the other hand, usually define it in net terms, that is, as the difference between assets and commitments in current account. These commitments are the debts to be liquidated during the year in the normal course of the enterprise's operation (for example, overdrafts and other short-terms bank documents, accounts payable, ond others). Thus the use of net working capital implies the idea of short-term financing, by means of various types of credit.

Both concepts must be considered in the preparation of projects. For analysis purposes, the economist wants to know the total investment involved. Inventory goods are those taken out for consumption, since although they circulate and "move" throughout the year, a part of their volume remains always outside the consumption circle, and as some values leave one end of the productive chain, others enter to take their place. On the other hand, the benefits which the investor will receive from his own capital are important to him, and he is interested more in the expression of capital in net terms. The latter is closely linked to the problem of short-term financing, which will be more difficult to define—because of its nature—than long term.[11] Nevertheless, if local conditions are known, some estimate can always be made of the liabilities in current account.

The amount of stock shown on the inventory is closely related to the technical aspects of the project. Continuous manufacturing processes eliminate the necessity for storage installations for work in progress. Warehouse facilities will only be required at each end of the production line. Intermediate stocks are thus eliminated and the amount of working capital reduced. Similarly, more efficient transport systems mean less materials in stock and in transit, both as regards distribution and supply. The technical aspect has, therefore, considerable influence on working capital.

[11] For example, it will not be easy to estimate *a priori* the amount of the bank overdraft which will be approved, nor the volume of accounts payable.

Obviously, however, technical factors do not alone determine the financial requirements of operation. Other important aspects are the credit policy of the enterprise, both as regards purchases and sales, and the distribution methods chosen.

In certain projects, working capital is either unnecessary or insignificant. Thus, for example, in building projects, the true operating expenses are those required to install air conditioning, heating, hot water and refuse incinerators. Such items are obviously so small in comparison with the total cost that the working capital is not worth considering. These expenses and those of maintenance of the building will normally be financed from the income which it produces, and no special fund need be formed of working capital. The administrative expenses of enterprises of this nature will be covered in the same way.

On the other hand, working farm capital is very important. In an agricultural project, the growing seed is equivalent to the goods being processed in industry. Because of irregular selling periods, working capital must cover all expenditures between harvests.

### 4. *Foreign currency in the investment*

A part of the investment will normally be in foreign currency, whether for equipment and other components of the fixed investment, or because of the need to maintain stocks of goods. The project must specify the amounts to be invested in national and foreign currencies in order to estimate the direct effect on the balance of payments. The foreign exchange component is generally a limiting factor, and it must therefore be assessed accurately. This is often necessary, too, in order to obtain the required import permits, or to carry out other operations resulting from the limited availability of foreign exchange.

### 5. *Investment schedule*

On the basis of the work programme it is possible to prepare an investment schedule (both for national currency and for foreign exchange), which will be the starting point for the financing study of the project.

## III. Allocation of investments in multi-purpose projects

### 1. *Nature of the problem*

In multiple projects the common investment must be divided between the different objectives. The way in which this problem is solved may have considerable effects on policy decisions relating to the assignment and distribution of funds for public works. If such funds are allocated for a scheme which simultaneously provides irrigation and electric power, the amount set aside for each purpose will affect the fixed costs of obtaining water and electricity and also the rates charged for both commodities. On the method of allocation will therefore depend whether water is dearer or cheaper than electricity. The question has been discussed at times in terms of State intervention or free enterprise, and has led to many political controversies about public investment policy and the rates charged for public utility services.

In the under-developed countries, the problem is not so far-reaching, although the same differences of opinion are liable to arise. There, the majority of multi-purpose works—irrigation, flood control, and electricity generation—are almost invariably in the hands of the public sector. The need for these services is so great that price variations arising from differences in allocations will not have any practical significance. State participation in these projects may mean that the problem of the rates charged can be solved by the granting of subsidies, or by the absorption of possible financial losses by the public sector.

Apart from its financial implications, and considering only its economic repercussions, the multi-purpose project may be conceived simply as a complex of various investment projects. For evaluation purposes, the joint investments and the joint benefits are the vital considerations, and the problem of the rates charged for a given service loses its significance within the over-all appreciation of the project. On the other hand, this problem acquires importance when the indirect effects of service rates are considered. Therefore it may be that high water rates would result in greater care in its use by the farmers, which in turn may lead to better use being made of the whole irrigation system.[12] Similarly, cheaper electricity may facilitate the installation of a series of industries whose production would more than compensate for the lower rate. To sum up, if a public project is involved and if it is desirable and practical to follow a certain rate policy, this policy may be adopted regardless of the way in which investment is apportioned, thereby reducing the importance of the task from this point of view.

The methods of apportioning the investment are important in the analysis of technical alternatives for the production of specific goods or services, since at least a preliminary approximation of the volumes of investment required to achieve each of the purposes of a multiple project is needed. It will therefore always be necessary to distribute the investments as reasonably and significantly as possible.

There is still no final solution to this problem. The authors who have dealt with the subject admit that there will almost always be an element of judgement or specific circumstances which cannot be translated into formulae.

Whatever the method of apportionment used, it is only applied to those investment items which are used for more than one purpose. Items which by their nature have a specific part to play in the project, related to only one of the objectives, are not included when calculating the apportionment. Shipping locks, or improvements in rivers to make them navigable, may be classified directly as investments in shipping facilities. Similarly, parts of dams which are constructed specially for water control are classified directly under control projects, while electric energy plants are clearly investments for the sole purpose of producing electricity.

The problem of apportioning costs therefore only concerns that part of the investments which serve more than one purpose. In irrigation works, for instance, the most important of these multi-purpose projects will usually be the dams and reservoirs, excepting such parts of the structure as are intended for specific single purposes.

[12] Under different circumstances, the opposite policy might be the better.

## 2. *Methods of apportionment*

The apportionment of costs is divided into the following stages: (*a*) preparation of the investment budget, detailing all items; (*b*) grouping of the items which are for the same specific purposes, and those which have multiple uses so that the direct costs for each objective are distinguished from those which must be allocated for multiple objectives; (*c*) apportionment of costs which still are not defined, in accordance with a determined procedure; (*d*) addition of the direct costs to those which have been apportioned, thus obtaining the total costs of each objective.

Some of the most commonly mentioned methods of apportioning investment costs for multi-purpose projects are the following:[13] (*a*) the justifiable alternative costs method; (*b*) method based on sales; (*c*) method based on the use of the installations; (*d*) method of priority of use; and (*e*) method of direct costs ratios.

### (a) *Justifiable alternative costs method*

This procedure consists in apportioning the common investment in terms of what it would cost to obtain the benefits of each of the objectives in the multiple project, by means of separate projects.

The most economic alternative cost of each of the objectives, which in all cases must be "justifiable", must therefore be ascertained. The justifiable limit of the alternative investment is understood to be that which does not exceed the capitalized value of the benefits which it would provide. Suppose that it were a project for the irrigation of 20 000 hectares, and ahat the resulting net benefits would be 1 000 monetary units (m.u.) per hectare, where net benefits are the difference between the value of the agricultural production and that of the costs of obtaining such production. The total benefit would then be 20 million m.u. Assuming that improved control of the saline content of the soil, and other benefits, yield 2 million m.u. per year, the total benefits resulting from the project would be 22 million m.u. If the project were to last 100 years, these benefits would be obtained for that period. To determine the present worth of a series of 100 annual amounts, they must be calculated with a certain rate of interest.[14] If a rate of 6 per cent is used, the capitalized or realized value of the 100 annual amounts of 22 million each would be 1 386.6 million. In other words, if the annual profit, the rate of interest and the life of the project are known, the total capitalized value will show the investment which would be justified if the enterprise in question were to obtain that rate of interest. In the example, if the benefits or profits are 22 million annually, and if a minimum profitability of 6 per cent is required, the maximum justifiable investment, in round figures, would be some 1 400 million m.u.

Thus, for the purpose of apportionment, the alternative investment will be taken to be that assessed for an alternative project, or the capitalized value of the estimated benefits. The lower of the two will be taken, and if there is no actual alternative project, a theoretical estimated capitalized value will be taken, based on estimated net benefits.

Arithmetically, this method of apportionment may be summarized as follows: suppose that a project is being examined with multiple objectives *a, b* and *c*, where *I* is the total investment in the project, to be allocated between the various objectives. *AI, BI* and *CI* are the portions of the investment *I* which are directly attributable to objectives *a, b* and *c* respectively. If *S* is the sum of $AI + BI + CI$, then $(I - S)$ will represent the investment to be allocated.

Now $A_2$, $B_2$ and $C_2$ are the justifiable investments in individual projects to achieve the same objectives *a, b* and *c*, and *T* is the sum of these. The "justifiable differences" are those obtained by subtracting from the single investment (for example $A_2$) that part directly attributable in the multiple project (AI). These will be shown as follows, where *D* is the sum of the partial differences:

*Justifiable differences*

$$\begin{aligned} DA &= A_1 - A_2 \\ DB &= B_1 - B_2 \\ DC &= C_1 - C_2 \\ \hline D &= T - S \end{aligned}$$

To allocate the difference $(I - S)$, the percentages represented by each one of the justifiable differences in the total difference are calculated. If these are *PA, PB* and *PC,* then

$$\begin{aligned} PA &= DA/D \\ PB &= DB/D \\ PC &= DC/D \end{aligned}$$

Multiplying $(I - S)$ by PA, PB and PC, the allocation of that part of *I* which has no specific assignation is obtained. The total investment *I* of the multi-purpose project will then be divided as follows:

For objective *a*: $(I - S) \times DA/D + AI$
For objective *b*: $(I - S) \times DB/D + BI$
For objective *c*: $(I - S) \times DC/C + CI$

### (b) *Method based on sales*

In this method the common investment costs are apportioned in proportion to the sales resulting from each objective. The obstacles to the application of this method derive chiefly from the difficulty of measuring the hypothetical volume of sales. Electric power is usually sold at a certain price, and the value of sales may be taken from the output in kWh. It is much more complicated to define and measure the hypothetical value of benefits obtained from flood control or of installations to make a river navigable. It is a difficult task to price services which are not marketed, or which are intangible.[15]

Doubts have also been expressed as to whether it is fair to relate the investment costs to sales volume, especially when the selling prices are not a result of the free play of supply and demand, as in the case of controlled electricity charges.

[13] A committee of consultants specially engaged by the Tennessee Valley Authority arrived at the conclusion that there is no single method which gives entirely satisfactory results, but amongst those examined the most useful is that of justifiable alternative expenses. See Newton B. Dicks, *Cost Allocation for Multiple Purpose Projects,* March 1955 (mimeographed document).

[14] See the comments on financial equivalents in Part Two, chapter II, section I.

[15] For instance, value from a tourist point of view, or for fishing and hunting.

(c) *Method based on the use of the installations*

Under this system, the investments are apportioned according to the use to be made of the common installations for each of the objectives. If, for example, the project is a dam, the use may be defined and measured in terms of the volume of the reservoir, or the amount of water used. If the use is expressed in this way, it may be imagined that the reservoir is divided into a series of horizontal strips, each for a different objective. Thus, for flood control, the height of water should not pass a certain level. On the other hand, to ensure a certain depth of water in a navigable channel, or to maintain a certain production of electricity, an adequate minimum must be maintained. It may therefore be assumed that the upper section of the reservoir is that part of the common installation which serves the flood control objective, and the common costs may be divided on the basis of storage capacity.

According to this criterion, each horizontal layer is assigned a specific use, and to each use is assigned the cost of storing that layer. When the same layer is used for more than one objective, a secondary allocation is made between objectives, based on the amount of water used. It is obvious that both the theoretical division into layers, and the proportion of water used in a specific layer for various objectives, involve arbitrary measurements. If the water which flows through penstocks to a power station is also used to improve navigation facilities, how much water may fairly be estimated for each use? Further, even assuming that the proportions of water for one use or another may be measured objectively, they will vary in any case from year to year, because of other factors such as rainfall. A new arbitrary element therefore appears in the calculation, when a choice must be made between one year or another, or an average of a number of years.

(d) *Method of priority in use*

It is accepted in this method that, because of special circumstances, one or more objectives of a multiple project will have priority, and that installations and works for other objectives must be satisfied by any possibilities which remain after meeting the requirements of the primary aim. For instance, if navigation and flood control needs are to have priority, then the head of water required for a power station dependent upon the same works must be a secondary consideration.

In the case of the Tennessee Valley Authority (T.V.A.), the electric power took second place not only in planning, but also during operation. In accordance with the instructions received by the chief engineer, the flow of water from the reservoir is first adjusted to the needs of navigation and flood control. No storage or discharge of water for the power station is permitted if it is not compatible with the increase required for navigation, or the reduction called for by flood control.[16]

The foregoing appears to justify allocating to the secondary objective only the increased costs it involves, over and above the costs which would in any case be incurred in meeting the primary objectives.

One of the objections which has been raised to this method is the ambiguity of the "increased costs" required to attain the secondary objective, and the various assumptions which must be made in order to compute these costs. A further objection is that the costs imputed to the secondary objectives may be too low, and therefore conflict with the true facts.

(e) *Method of direct costs ratios*

The common investments are allocated in the same proportion as those which have a specific objective. If $A$, $B$ and $C$ are the direct investments in each objective, their sum $S$, and $P$ the common investments, then $P$ will be allocated in the same proportions as are $A$, $B$ and $C$ in $S$.

The objection to this method is that there is no reason why there should be any relationship between the common functions say, of a reservoir, and the cost of each of the specific installations forming part of the project. The method may be used as a first approximation, if there is no basis for a more satisfactory solution.

[16] See Newton B. Dicks, *op. cit.*

## Illustrative cases

### *Case 29*

### Calculation of investment in a beet-sugar mill

#### 1. *Summary of investments*[1]

In the summary of the project, the investment budget was presented in the form shown in table 66.

#### 2. *Method of calculation*

(a) *Engineering costs*

All the administrative and technical costs involved in executing the project, up to the point where machinery installation begins, are included under this heading. It was estimated that this stage would last 15 months, and salaries were calculated for this period for the technical and administrative staff and for the legal advisers. During this construction stage, the *Corporación de Fomento,* which had sponsored and financed the project, provided the administrative facilities.

The value of these facilities was not calculated, although in fact they form part of the investment. Nor was the project charged with the Corporation's expenses in the study prior to the actual construction stage (salaries of engineers and economists and cost of the research on sugar beet cultivation). From the time when machinery began to be installed, administrative and technical costs were included under the heading of equipment installation, which is explained later. It was estimated that after that stage had been reached, the course of the work would change and a more delicate and intensive phase would begin, requiring

[1] The same terminology is used as in the original project. In connexion with this same project, see also cases 19 and 23.

Table 66

CASE 29. INVESTMENT BUDGET FOR A BEET-SUGAR MILL

*(Millions of monetary units)*

| | |
|---|---|
| I. *Construction and installation costs*: | |
| Construction engineering costs | 5.21 |
| Organization and legal expenses | 1.00 |
| Land and urbanization | 12.00 |
| Electrical connexion | 3.00 |
| Railway branch line | 10.00 |
| Camp | 3.20 |
| Warehouses and stores | 6.86 |
| Offices and workshops | 9.80 |
| Vehicles, scales and miscellaneous | 6.20 |
| Workers and employees' houses | 23.00 |
| Water installation | 3.00 |
| Plant buildings | 14.60 |
| Equipment installation | 37.19 |
| Inland freights | 2.00 |
| Running-in period | 4.87 |
| Contingencies | 15.07 |
| Total installation | 157.00 |
| II. *Cost of equipment (c.i.f.)*: | |
| 3 million dollars at 60 monetary units | 180.00 |
| III. *Interest before entry into operation* | 25.41 |
| IV. *Working capital* | 40.00 |
| Total investment | 402.41 |

more personnel and different technical needs. The method of dividing engineering and administrative costs reflects these two phases, which are explained in detail in the annexes to the project.[2]

(b) *Organization and legal costs*

These have already been dealt with.

(c) *Land and urbanization*

Of the 12 million appearing in the table, 1 really covers land and the remaining 11 paving, drainage, etc.

(d) *Electrical connexion, railway branch line and water installation*

These form part of what was termed in the general comment "auxiliary engineering works". The electrical connexion refers to the connexion of the factory under construction with the high-tension lines of the public service network. The over-all cost was estimated after verbal consultations with experts from the electricity enterprise. Knowing the distance from the connexion point, the network's voltage and power, and some other local details, a sufficiently close estimate could be made for the preliminary calculation of the investment. Included among the engineering costs charged to the project, according to the item already discussed, was the payment of technical staff to make the final studies and arrange the details for making the connexion.

The over-all cost of the railway branch line was estimated on the basis of the length and cost per kilometre of railway track.

A first engineering project was available for budgeting the water installation. The pumps and pipes were included in the general list of equipment, and the labour was considered as being included in the general installation costs. The item therefore only includes the materials needed to build a small water intake, a channel for a given water supply, a supply tank for the pumps and an outlet channel for the used water.

(e) *Camp*

The investment of 3.2 million is broken down into 0.2 for installation work, and 3 million for a shed, which will later be used to house those workers who only work during the annual period of production.[3] This shed would be used as living quarters for the construction workers. Its value was estimated according to its total area and the cost per square metre.

(f) *Stores, offices and workshops, factory buildings, silos and molasses deposits*

Some conventional criteria also had to be used to calculate this item. They are based on the project's peculiarities and on the method of organizing the study. At the beginning, it was noticed that part of some buildings had been contracted along with the machinery, because the tenders for the latter included certain metallic structures for industrial buildings and stores. To decide which buildings would be made with metal structures, the supplier was awarded contracts for them as well as for the layout and installation of machinery and equipment. For these buildings, only the value of sheet piling and finishing was added to the budget. The other buildings were budgeted complete under one single heading.

Other industrial buildings and constructions included the following: store for general materials, distillery, repair workshops, offices, entrances and weighing sheds, pump houses, garage, beet silos and buildings to house the molasses tanks. The cost of the furniture and equipment for the offices and the machinery for the workshops was included under the heading of "offices and workshops". Actually, of the 9.8 million included under this heading, only 2.8 was for buildings and the remaining 7.0 for equipment.[4]

(g) *Houses for workers and employees*

This item was calculated in terms of the number of employees and workers and the built-up space considered necessary per family, and an over-all budget was made based on a given building cost per square metre. Final plans were to be made later, so that architects' fees were included under the item "engineering costs".

(h) *Vehicles, weighing machines and sundry items*

This item includes light and heavy lorries, weighing machines and other elements needed for operating the enterprise. Among them are included fire-fighting equipment.

[2] It will be appreciated that the structure of the items is entirely conventional and often depends on the order in which the subjects were studied and presented.

[3] The mill only works 100 days per year, so a distinction is made between seasonal workers who only work during that period, and permanent workers.

[4] The conventional form of presentation may again be observed. For reasons of homogeneity it would have been preferable to bring together all items relating to equipment, and separate them from those relating to buildings; in this way, metal structures would not form part of equipment nor would workshop equipment form part of buildings.

(i) *Assembly*

It can be seen from the table that this is the largest item among installation costs. It consists of the following:

| | *Million* |
|---|---|
| Foreign assemblers | 8.22 |
| National employees | 4.78 |
| National workers, materials and sundries | 24.18 |

Payment to foreign assemblers was estimated on the basis of the number and composition of the technical personnel to be contracted abroad, and the salaries they would have to receive in dollars. Overtime, travel and life insurance, payments for lodging and food were reckoned in local currency.

As for the national employees, it was explained at the beginning that the assembly of equipment signified the beginning of a new stage that would require more technical and administrative personnel. To the manning table originally considered under the item "engineering and administration", another was added which would complete the enterprise's technical personnel for the construction period. These would be approximately the same as would subsequently continue working when the industry was operating normally. Also included under this item were the agronomists who would begin the work of contracting crops with the farmers, and all administrative personnel for the assembly stage, which was to last 8 months.

The cost of labour during the assembly stage was estimated on the basis of over-all assessments based on similar experiences in other countries, since this was the first factory of its kind to be built in the country.

The labour budget consisted of the following:

| | *Million* |
|---|---|
| 150 skilled workers for 240 days, including overtime, holiday work, social security costs, insurance, etc. | 12.28 |
| 250 labourers for 240 days, with the same additional charges | 7.72 |
| TOTAL FOR LABOUR | 20.00 |

The wages assigned were those normally paid in the locality, plus a safety margin. Materials and sundry items included in the assembly costs comprised miscellaneous materials, rent and depreciation of building equipment that might be needed.

(j) *Domestic freight*

This item covers the freight on imported equipment from the port of disembarkation to the works. Materials of domestic origin included under other items were quoted placed at the works.

(k) *Running-in period*

In the work schedule it was estimated that the running-in period for the industry would last 2 months, during which the installations would be tested, manufacturers' guarantees would be checked and all drawbacks and defects found in the tests would be corrected.

The corresponding costs were estimated as follows:

| | *Million* |
|---|---|
| Employees (the same as during the assembly period) | 1,195 |
| Workers | 1,512 |
| Assemblers | 1,561 |
| Materials | 0,600 |
| TOTAL | 4,868 |

(l) *Unforeseen Contingencies*

Ten per cent of all the preceding items was taken to cover this.

### 3. *Regrouping of some items*

As has just been seen, the items corresponding to engineering costs are grouped very conventionally. Later on, some items were regrouped to show their influence on the general installation costs, the results being shown in table 67. This time, engineering costs included the salaries of the technical personnel, and some of the agronomists and architects. Those relating to organization of the enterprise, subsistence rates, office expenses and salaries of administrative personnel during the installation period were considered as overheads. The temporary camp for the construction work was also included.

### 4. *Cost of equipment*

The cost of imported equipment was estimated at 3 million dollars c.i.f. on the basis of tenders obtained from several suppliers. The highest prevailing exchange rate was used. Customs duties were not included because this was a new and legally exempt industry which, moreover, belonged to the public sector.

### 5. *Interest until the running-in period*

Under this item, the project considered interest on capital invested during the installation, from the time of the investment until the starting-up of the factory. The interest calculations were divided into two parts, depending on whether the investment concerned installation or imported equipment.

(a) *Interest on installation investments*

First of all a complete investment schedule was drawn up, month by month, and then the monthly figures were used to obtain quarterly investment amounts. The interest rate adopted was 6 per cent; the period was considered to

**Table 67**

CASE 29. DISTRIBUTION OF THE INVESTMENT

*(Millions of monetary units)*

| *Items* | *Amount* | *Percentage of the total investment* |
|---|---|---|
| Engineering | 8.2 | 2.5 |
| General | 3.0 | 0.9 |
| Tests and running-in | 4.9 | 1.5 |

CASE 29. INTEREST ON INSTALLATION COSTS UP TO ENTRY INTO OPERATION

*(Millions of monetary units)*

| Quarterly partial sums | Period | Interest: Total rate (6 per cent annually) | Interest: Amount |
|---|---|---|---|
| 20.69 | 24 | 12.0 | 2.48 |
| 13.78 | 21 | 10.5 | 1.45 |
| 12.75 | 18 | 9.0 | 1.15 |
| 15.95 | 15 | 7.5 | 1.20 |
| 12.68 | 12 | 6.0 | 0.76 |
| 36.32 | 9 | 4.5 | 1.63 |
| 29.98 | 6 | 3.0 | 0.66 |
| 22.86 | 2 | 1.0 | 0.23 |
| 157.01 | | | 9.56 |

be from the middle month of the quarter to the date estimated for starting-up. This led to the results in table 68.

Consequently, 9.56 million are added to the original investment for installing the industry, to cover interest during the construction period.

### (b) *Interest on the investment in machinery*

It was assumed that this part of the investment would be financed partly through certain credit facilities granted by equipment suppliers. Even so, a large part of the machinery would be paid before the starting-up of the factory. The procedure was to charge to investment that part of the interest corresponding to credit on machinery paid for before the entry into operation, and credit on that paid afterwards to operating costs.

Table 69 gives the schedule in partial quarterly amounts. By adding to the interest imputed in the table that actually paid to the suppliers before the entry into operation (5.6 million), the total interest on machinery investments is found (15.85 million).

Briefly, then, interest on capital tied up during the construction period is:

**Table 69**

CASE 29. INTEREST ON THE EQUIPMENT INVESTMENT UP TO ENTRY INTO OPERATION, AT 6 PER CENT PER ANNUM

*(Millions of monetary units)*

| Quarterly partial amounts: cash quota, amortization of credits, freight and insurance, and interest on credits paid to suppliers | Period (months) | Percentages | Interest charged to the investment |
|---|---|---|---|
| 40.50 | 26 | 13.0 | 5.27 |
| 6.00 | 17 | 8.5 | 0.51 |
| 46.50 | 14 | 7.0 | 3.26 |
| 6.00 | 11 | 5.5 | 0.33 |
| 19.30 | 8 | 4.0 | 0.77 |
| 10.60 | 2 | 1.0 | 0.11 |
| 128.90 | | | 10.25 |

| | |
|---|---|
| Interest on installation capital. . . . . . . | 9.56 |
| Interest on equipment capital. . . . . . . . | 15.85 |
| TOTAL | 25.41 |

The suppliers' credit was for a relatively short period — 5 years. Some 65 per cent of the equipment would have been already paid for at the moment of starting up; as already indicated, it is conventional to assume that the interest on the remaining 35 per cent forms part of the financing costs, since the enterprise is now operating. Another criterion that might be adopted would be to charge to fixed investment costs all interest incurred in financing, whether paid before or after the factory starts up.[5]

## 6. *Working capital*

The working capital was based on the enterprise's monthly cash turnover, in accordance with the estimated balance for a normal year, that is, operating at full capacity.

The amount of working capital adopted in the preliminary calculation of investments in the project is shown in table 70, 71 and 72. The first of these represents monthly distribution of estimated annual expenditure for the enterprise's period of operations. Table 71 compares these expenses with income, also distributed monthly. The difference between accumulated monthly income and expenditure as shown in the table gives the maximum cash requirements to make up the working capital. Table 72 shows the same type of calculation, but considering only the month by month income and expenditure and the cumulative figures.

Some additional explanations follow as to the method of preparing the tables.

In the case of table 70, the horizontal lines indicate monthly expenses for the items corresponding to the vertical columns.[6] The totals for each column correspond to the estimated budget items for the enterprise's income and expenditure. These sums are distributed over the various months of the year according to the way in which the industry's activities are expected to develop. For instance, salaries were distributed evenly throughout the year; this was not so with wages, since part of them correspond to those paid during the production period which lasts some 100 days, whereas the other part corresponds to a period when the factory is not working. Payments for sugar-beet, which is the principal raw material, were distributed according to the dates on which crop advances were paid to the farmers for purchase of seed, the harvest dates and the liquidation dates. The cost of coal and other materials was distributed in such a way as to ensure the supply needed for the start of the season, assuming that when the annual work began, all the materials would be in the stores. The operating period will last from mid-April to mid-July.

[5] The difference affects other financial calculations. Actually, if interest on credits by equipment suppliers are charged to operating costs it assumes that this part of the investment is amortized over a very short period (in exactly those periods when payments fall due for the equipment, plus interest). On the other hand, if they are added to the investment from the beginning, and are not considered as operating costs, they will be amortized together with the equipment, that is, over a longer period. Although the differences in the total calculations are not great, it is as well to bear them in mind for reasons of method.

[6] Table 70 is shorter than the one in the original study, as some columns have been merged to simplify the explanation.

## Table 70

CASE 29. ESTIMATED MONTHLY EXPENDITURES[a]

*(Monetary units)*

| | *Salaries wages, subsistence and taxes* | *Beet, including freight, reception and handling* | *Coal, lime, coke, sacks and other materials* | *Insurance and depreciation reserves* | *Profits* | *Monthly expenditure* | *Cumulative expenditure* |
|---|---|---|---|---|---|---|---|
| July | 1 641 | 8 000 | 1 000 | — | 39 554 | 50 195 | 50 195 |
| August | 1 690 | 10 000 | 1 000 | — | | 12 690 | 62 885 |
| September | 1 690 | 10 000 | 2 000 | — | | 13 690 | 76 576 |
| October | 1 664 | | 1 000 | | | 2 664 | 79 240 |
| November | 1 616 | | 1 000 | | | 2 616 | 81 856 |
| December | 1 616 | | 3 074 | | | 4 690 | 86 546 |
| January | 1 664 | | 5 922 | | | 7 586 | 94 132 |
| February | 1 664 | | 3 763 | | | 5 427 | 99 559 |
| March | 1 664 | | 2 849 | | | 4 513 | 104 072 |
| April | 2 739 | 17 800 | | | | 20 539 | 124 611 |
| May | 2 739 | 17 800 | | | | 20 539 | 145 150 |
| June | 2 739 | 18 812 | | 6 516 | | 28 067 | 173 217 |
| Total | 23 127 | 82 412 | 21 608 | 6 516 | 39 554 | 173 217 | |

[a] Approximate figures; the differences have been rounded-off.

Payment of insurance and of amortization reserves will be made in June, when it is assumed that the enterprise will be selling and will have a sound cash situation.

In the expenditure table, it was estimated that amortization reserves would in fact come from cash, as if they had been deposited in a bank at compound interest in order to reconstitute the capital formed by them. This line was adopted because the depreciation reserves were calculated in cumulative terms. Actually, these reserves could remain in hand and serve as working capital so long as interest was paid on them each year, in order once more to accumulate the capital to be amortized. This would be the equivalent of the enterprise acting as its own banker with its amortization reserves.[7] Finally, the total gross profits were assumed to be made by July, the last month of the season, when sales had reached their peak.

The distribution of income was prepared in similar fashion (see table 71). Income will come from sales of sugar, alcohol and cossettes (beet residues). The seasonal nature of the industry can be appreciated, as for five months of the year, according to the table, it will receive no income.

To facilitate the explanation, all the monthly income and expenditure has been summarized in table 72. The monthly cash deficit or surplus has been calculated, the accumulated deficit being entered in the last column, revealing the company's cash requirements. The figures are given as from July, and this arrangement shows a maximum cumulative deficit of nearly 35 million, thus reflecting, it was felt, the company's real position.

It is interesting to observe that if the figures in the table had been arranged as from May, there would be a continuous cash surplus, since sugar sales would commence before the preceding costs had been paid. This situation would be the equivalent of having postponed the payment of the production factors, and is naturally unrealistic. The maximum cumulative cash deficit is obtained if the figures are grouped as from September. It amounts to 36 million, almost the same as that accepted by the authors of the report. On the basis of the above analysis, the project estimated that the enterprise would be able to manage with a working capital of 40 million. The reasoning used

[7] See Part One, chapter VI.

## Table 71

CASE 29. CASH TURNOVER ACCORDING TO ESTIMATED BALANCE SHEET

*(Monetary units)*

| | *Accumulated expenditure*[a] (A) | *Month's income* (B) | *Cumulative income* (C) | *Cash requirements* (A - C) |
|---|---|---|---|---|
| July | 50 195 | 41 660 | 41 660 | 8 535 |
| August | 62 885 | 22 473 | 64 133 | — 1 248 |
| September | 76 576 | 3 288 | 67 421 | 9 155 |
| October | 79 240 | 3 288 | 70 709 | 8 531 |
| November | 81 856 | — | 70 709 | 11 147 |
| December | 86 546 | — | 70 709 | 15 387 |
| January | 94 132 | — | 70 709 | 23 423 |
| February | 99 559 | — | 70 709 | 28 850 |
| March | 104 072 | — | 70 709 | 33 363 |
| April | 124 611 | 19 187 | 89 869 | 34 715 |
| May | 145 150 | 41 660 | 131 556 | 13 594 |
| June | 173 217 | 41 660 | 173 216 | — |

[a] See table 70.

Table 72

CASE 29. MONTH-BY-MONTH INCOME AND EXPENDITURE[a]

*(Thousands of monetary units)*

| | *Income* | *Expenditure* | *Deficit* | *Surplus* | *Accumulated deficit* |
|---|---|---|---|---|---|
| July | 41.6 | 50.2 | 8.6 | — | 8.6 |
| August | 22.5 | 12.7 | | 9.8 | — 1.2 |
| September | 3.3 | 13.7 | 10.4 | | 9.2 |
| October | 3.3 | 2.7 | | 0.6 | 8.6 |
| November | — | 2.6 | 2.6 | | 11.2 |
| December | — | 4.7 | 4.7 | | 15.9 |
| January | — | 7.6 | 7.6 | | 23.5 |
| February | — | 5.4 | 5.4 | | 28.9 |
| March | — | 4.5 | 4.5 | | 33.4 |
| April | 19.2 | 20.5 | 1.3 | | 34.7 |
| May | 41.6 | 20.5 | | 21.1 | 13.6 |
| June | 41.7 | 28.1 | | 13.6 | — |
| Total | 173.2 | 173.2 | 45.1 | 45.1 | |

[a] Round figures.

was that in addition to the cash needs shown in the table, a volume of materials had to be kept permanently in store—spare parts, various materials, etc.—since purchases could not be strictly adjusted to the amounts used in production. On the other hand it was assumed that short-term requirements would be met with bank credits, interest on which would be offset by the interest charged to the farmers for the crop advances.

The case just explained covers a very special type of industry and is not the kind most frequently found. The enterprise will produce during only 100 days of the year and will remain inactive during the rest. Hence the need to carry out an estimate of the monthly development of cash requirements. The figures obtained only provide a basis for estimating working capital requirements, adjusted to the industry's particular needs.

## *Case 30*

### CALCULATION OF WORKING CAPITAL FOR A COPPER-SMELTING PROJECT

This deals with the method used to calculate the amount of working capital in the case of a copper smelter, a project which has already been discussed in terms of the study of its size and the request for tenders.[8] The method of procedure has been summarized in table 73, special attention being drawn only to the following points:

*Ore stocks.* The smelter will be supplied from a series of small and medium mines, some of which are very far away and have to send their ores by sea. Moreover, in view of the different mineral content of the ores, considerable stocks have to be available to prepare the smelter charge.

*Immobilized copper.* This item is derived from the technical need of keeping a certain amount of copper in the furnace.

*Copper in transit.* Since this is an export industry, the cycle had to be considered until payment for sales is received. It can be seen that this is the largest item; it takes up half the working capital.

[8] Cases 13 and 26.

Table 73

CASE 30. CALCULATION OF WORKING CAPITAL FOR A COPPER SMELTER

*(Thousands of monetary units)*

| *Item* | *Amount* |
|---|---|
| I. Mineral stocks for two months[a] | 494 109 |
| II. Immobilized copper[b] | 20 700 |
| III. Copper in transit, until receipt of payment[c] | 925 500 |
| IV. Two months' fuel | 50 730 |
| V. Warehouse stocks[d] | 60 000 |
| VI. Operating expenses (for three months) | 157 560 |
| VII. Precious metals[e] | 182 071 |
| Working capital | 1 890 670 |

[a] 7 500 tons of concentrates, 11 200 of ore and 5 200 of fluxes.
[b] 1 000 tons in circulation within the furnace.
[c] Blister copper produced in three months, accepting this as the cycle between the entry of the ore into the furnace and receipt of payment for sales.
[d] According to experience.
[e] Gold and silver content of copper bars covering 5 months' supply (stock and transit up to receipt of payment).

*Advances.* The possibility must be considered of obtaining an 80 per cent advance on the material in transit. Once this deduction has been made, the net working capital is obtained. The advance would be 740.4 million (80 per cent of Item III in the table) so that the net capital would be reduced to 1 150.3 million monetary units.

## *Case 31*

### DESCRIPTION AND INVESTMENT BUDGET FOR A CEMENT FACTORY PROJECT

The following example comes from the project already described[9] which was presented to the International Bank for Reconstruction and Development for the building of a cement factory at Pacasmayo, Peru. Here only a brief description will be given of it, together with the budget. The final presentation to the International Bank was based on the technical studies of a firm of consulting engineers, with the data supplied by equipment manufacturers and the field surveys undertaken by the Bank's staff.

[9] Cases 8 and 42.

It concerns a cement factory with an annual productive capacity of 100 000 tons (350 tons a day), situated at the port of Pacasmayo, in northern Peru. The factory will use the ordinary humid technical process. The limestone and clayey slate deposits which will supply the basic raw materials are located some 60 kilometres away by road from the site selected for the factory. The primary rock-crushing will be done at the quarry, and the crushed rock will be transported by lorry, using a recently paved road permitting year-round traffic.

The limestone deposit owned by the company covers an area of some 2 km². Exploratory drillings have proved the existence of 3.5 million tons of limestone, sufficient to supply the proposed factory for more than 25 years. Probable reserves—not yet proven—are estimated as between 100 and 300 million tons.

The clayey slate is also close by and reserves are estimated at 1 million tons, which is more than sufficient since only 15 per cent is required in relation to the limestone used. Gypsum will also be used in the industry in small amounts (4 per cent in relation to the cement) and will be obtained from a deposit some 150 km from the factory.

The fuel used will be oil from the Talara oilfields. It will be shipped by sea to Pacasmayo and pumped from there to the factory's tanks. The figures are summarized in table 74.

**Table 74**

CASE 31. ESTIMATED COST OF CEMENT PLANT[a]

| | | |
|---|---|---|
| *Investment in foreign currency* (dollars): | | |
| 1. Equipment for working limestone quarries | | 101 173 |
| 2. Equipment for working clay-slate deposit | | 26 349 |
| 3. Limestone crushing equipment | | 68 600 |
| 4. Power station and compressors for limestone quarry | | 43 883 |
| 5. Lorries for transport of raw materials | | 183 107 |
| 6. Feed hoppers, transporters, crushers and warehouse cranes | | 59 080 |
| 7. Grinding mill equipment | | 106 710 |
| 8. Pulp plant installations | | 35 170 |
| 9. Rotary kiln, with accessories such as: coolers, tanks conveyors, hoists and dust collectors | | 451 110 |
| 10. Refractory bricks for kiln lining | | 37 951 |
| 11. Gypsum crushing plant (hopper, receiver, crusher and conveyor) | | 7 134 |
| 12. Cement grinding equipment | | 90 090 |
| 13. Cement storage and packing installation | | 62 815 |
| 14. Oil storage and supply installations (tanker-lorry, storage tanks, piping and accessories) | | 44 203 |
| 15. Water installations (pumps, tanks, etc.) | | 33 930 |
| 16. Power station equipment, including: turbo-generator, boiler, control panels, diesel engine, cooling tower, etc.) | | 344 470 |
| 17. Electrical equipment, motors, transformers, transmission equipment | | 159 350 |
| 18. Laboratory equipment | | 18 000 |
| 19. Safety and first-aid equipment | | 2 600 |
| 20. Tools for the blacksmith's and electrical workshops | | 140 676 |
| 21. Steel structures for the plant | | 52 465 |
| 22. Handling materials, such as lorry weighbridge, etc. | | 6 880 |
| 23. Spares | | 128 000 |
| 24. Cost of technical services, supervision, plant erection, including 12 months' operation | | 330 475 |
| 25. Maritime freight and insurance | | 350 045 |
| 26. Interest on loan during construction | | 176 915 |
| 27. 10 per cent of foreign currency (1 to 25) for contingencies | | 288 420 |
| Total in round figures | | 3 350 000 |
| *Investment in national currency*: | | |
| 1. Items included in the offer of the equipment manufacturer: | | |
| (*a*) Disembarkation of equipment and transport to plant site | 944 566 | |
| (*b*) Installation tools and apparatus | 1 125 000 | |
| (*c*) Installation | 3 401 965 | |
| (*d*) Construction on site | 11 470 355 | 16 941 886 |
| 2. Insurance during installation | | 685 000 |
| 3. Administration during construction | | 500 000 |
| 4. Cost of preparation of lime kiln | | 100 000 |
| 5. Medical and safety installations | | 50 000 |
| 6. Transport equipment | | 380 000 |
| 7. Miscellaneous spares | | 150 000 |
| | | 18 806 886 |
| Contingencies (20 per cent) | | 3 700 000 |
| Working capital for three months | | 4 500 000 |
| Total in national currency | | 27 006 886 |
| | | 1 350 392 |
| Equivalent in dollars of the mining property and other national currency expenses | | 300 000 |
| Total national currency investment expressed in dollars | | 1 650 000 |

[a] Items 1 to 25 are according to the equipment manufacturer's quotation.

Table 75

CASE 32. SUMMARY OF THE TOTAL INVESTMENT IN A ZINC FACTORY

*(Thousands of dollars)*

| | *Expenses in pesos converted into dollars* | *Expenses in dollars* | *Total expenses in dollars* |
|---|---|---|---|
| A. *Direct plant costs, including construction labour* | 4 459 | 10 420 | 14 879 |
| 1. Zinc production | 2 127 | 3 995 | 6 122 |
| 2. Production of ammonium sulphate | 1 523 | 5 910 | 7 433 |
| (*a*) sulphuric acid | 240 | 960 | 1 200 |
| (*b*) ammonia | 1 110 | 4 485 | 5 595 |
| (*c*) ammonium sulphate | 173 | 465 | 638 |
| 3. Auxiliary projects | 809 | 515 | 1 324 |
| B. *Indirect plant costs* | 514 | 3 152 | 3 666 |
| 1. Engineering, purchasing and others (7.5 per cent of A) | | 1 115 | 1 115 |
| 2. General construction expenses (10 per cent of A) | 445 | 1 043 | 1 488 |
| 3. Freights, transhipments and insurance | | 600 | 600 |
| 4. Entry into operation | 69 | 394 | 463 |
| C. *Contingencies* (10 per cent of A + B) | 497 | 1 357 | 1 854 |
| D. *Total cost of plant* | 5 470 | 14 929 | 20 399 |
| E. *Working capital* | 1 220 | 925 | 2 145 |
| F. *Total investment* | 6 690 | 15 854 | 22 544 |

*Case 32*

PRESENTATION OF THE ESTIMATED INVESTMENT CALCULATIONS FOR AN INDUSTRIAL COMPLEX BASED ON ZINC PRODUCTION

This example provides an illustration of the way to carry out and present the investment calculations in the case of a project related to zinc production.[10] Briefly, it concerns an industrial complex of four factories: a zinc smelter, an ammonia plant, another for sulphuric acid and a fourth for ammonium sulphate to combine the acid with the ammonia.

The project gives no details concerning the method of obtaining the basic figures on equipment and installation costs, but it is a good example of presentation. It also shows the criteria employed to estimate the amount of such items as "engineering costs" and "overheads" during construction.

The total investment costs, classified as direct or indirect, are given in table 75. The former include the cost of equipment as well as installation and construction expenses. Indirect costs include: (*a*) the project engineering, purchasing expenses and others, all of which are estimated at 7.5 per cent of the direct investment; (*b*) general overheads—contractor's fees, temporary buildings, receiving and storage facilities, purchasing costs, supervision of the building stage and travelling expenses—which together are estimated at 10 per cent of the direct investment; (*c*) maritime freights, transhipments and insurance, which are estimated by multiplying the weight of the equipment by an average cost of 40 dollars per ton, and (*d*) running-in period (mechanical tests, final modifications and other administrative and supervisory expenses). It was estimated that, apart from the regular staff, the running-in period would require 4 specialists and 8 assistants to train the local staff and to solve the problems arising at this stage. To the preceding items, those for contingencies and working capital have been added. Contingencies were estimated at 10 per cent of total direct and indirect costs.

Table 75 shows the summary of the total investment, including working capital, broken down into its components in dollars and national currency. Table 76 shows the breakdown of the direct factory costs, dividing the investment into equipment and installation costs. Table 77 shows the detail of the expenses for the zinc factory, one of those forming part of the items in table 75. Table 76 shows the way in which the working capital was calculated. No detail of the other units is given because the model of presentation is the same.

[10] Case 22.

Table 76

CASE 32. COST OF THE PLANT INCLUDING CONSTRUCTION LABOUR (ITEM A OF TABLE 75)

*(Thousands of dollars)*

| | *Equipment* | *Installation and construction* | *Total* |
|---|---|---|---|
| Zinc plant | 3 494 | 2 628 | 6 122 |
| Acid plant | 800 | 400 | 1 200 |
| Ammonia plant | 3 882 | 1 713 | 5 595 |
| Ammonium sulphate plant | 350 | 288 | 638 |
| Auxiliary projects | 642 | 682 | 1 324 |
| Total | 9 168 | 5 711 | 14 879 |

Table 77

CASE 32. DETAIL OF INVESTMENTS (ITEM A-1 OF TABLE 10)

*(Thousands of dollars)*

| | *Equipment* | *Installation* | *Total* |
|---|---|---|---|
| Storage and handling of concentrates | 55 | 16 | 71 |
| Roasting and calcination | 625 | 220 | 845 |
| Storage and handling of calcines | 72 | 24 | 96 |
| Leaching and purification | 547 | 162 | 703 |
| Cells and cathodes | 498 | 180 | 678 |
| Lead-silver anodes | 550 | — | 550 |
| Rectifiers and electrical equipment | 1 047 | 490 | 1 531 |
| Smelting and moulding | 100 | 43 | 155 |
| Total | 3 494 | 1 135 | 4 629 |
| Buildings | — | 1 493 | 1 493 |
| Grand total | 3 494 | 2 628 | 6 122 |

Table 78

CASE 32. ESTIMATE OF WORKING CAPITAL (ITEM E OF TABLE 10)

*(Dollars)*

| | |
|---|---|
| I. 90 days' supply of ore concentrates | 656 000 |
| II. Ammonium sulphate (cost of one month's production) | 150 000 |
| III. Miscellaneous materials in warehouse | 790 000 |
| IV. Plant operating costs for two months | 549 000 |
| Total | 2 145 000 |

## *Case 33*

### Degree of accuracy and criteria employed for the preliminary estimate of the cost of a factory

To ensure that this example is confined to an illustration of the criteria employed for cost estimating, without seeking to show any methods of presentation or details of the calculations, the particular factory concerned is not indicated.

In dealing with the cost of the factory in the project, it should be remembered that in enterprises of this type, four estimates are usually made for the investment costs, in an increasing order of magnitude. The first estimate is simply a reasonable assumption based on average unit costs of capacity in similar factories. Its only purpose is to decide on the general financial possibility of undertaking a project. The second estimate takes into account the construction costs at the specific location and at the particular date of construction, but no up-to-date quotations for machinery and equipment are included. The prices of other existing factories are modified to cover local markets and conditions. The third type of estimate is the one normally used to attract investors and to form the capital, and is based on engineering plans carried to a reasonable degree of detail, but not as specific as would be needed for building purposes; as a rule, quotations and proposals from suppliers of the principal items are included. The fourth type is the estimate carried out for the final budget and is only made once a decision has been reached to build the factory. It is generally based on the plans of the preliminary project and on the actual contracts for supplying the principal equipment. Current labour prices are used, as well as the fees agreed upon with the contractors, etc. This final estimate is usually used for checking purposes during the construction of the factory.

In the specific case of the project under discussion, the investment is calculated according to the second type of estimate. As for the provision of equipment, only the main sizes and specifications are considered and its cost is deduced from similar equipment in existing factories. The unit prices for those factories were increased by 60 per cent to include both the inflationary effects of the war and the organization and construction costs within the country. A further 10 per cent was added to the equipment cost to cover unforeseen items and omissions. To the total thus obtained 12 per cent was added for engineering and administrative costs during the construction of the plant. A special item was also added for training personnel and another for housing the staff and their families.

The details of the calculation are presented in special tables, which specify the main items and their partial costs.

## *Case 34*

### Allocation of investments in twenty factories of different kinds

The next example represents an application of the allocation method known as "justifiable alternative investment". It is derived from the study of a committee of experts specially appointed to recommend a method in the case of the Tennessee Valley Authority.[11] As the various projects to which the study refers are so inter-dependent in their operation, they had to be considered together when allocating costs.

The application of the method followed the steps described in the text. For example, the justifiable alternative cost for each objective, considered separately, was estimated and it was decided which part of the investment was directly attributable to each objective in the multiple-purpose project. The total amount of the investment was 744.5 million dollars, of which 332.4 were directly attributable, according to the detail in column B of table 79. The over-all balance for allocation was, consequently, 412.1 million.[12] It can be seen that the percentages of the "balance of justifiable alternative cost" (percentage C) were multiplied by the total amount of common costs (412.2 million) and divided by 100 to obtain the values in column D. The total distribution of the investment is obtained by adding columns B and D.

## *Case 35*

### Investment budget and justification for a thermo-electric plant in Brazil

This is one of the power stations recommended by the Joint Brazilian-United States Economic Development Com-

[11] Newton B. Dicks, *Cost Allocation for Multiple Purpose Projects*, a document presented to the Knoxville Section of the National Cost Accountants Association, on 15 March 1955. The author is the assistant to the comptroller of the T.V.A.

[12] These investments cover the twenty multi-purpose factories comprised in the system and include the cost of the work of executing each one. The system also has a series of power stations with one sole purpose, which cost 544.7 million dollars.

Table 79

CASE 34. ALLOCATION OF ESTIMATED COSTS OF INVESTMENTS IN THE TENNESSEE VALLEY AUTHORITY ACCORDING TO JUSTIFIABLE ALTERNATIVE COST METHOD[a]

| *Use* | *Justifiable alternative cost* (A) | *Directly attributable portion of investment* (B) | *Alternative justifiable balance*[b] *Amount* (C=A—B) | *Percentage of C Part C / Total C* | *Allocation of common costs*[c] (D) | *Distribution of total investment* (E=B+D) |
|---|---|---|---|---|---|---|
| Navigation . . . . | 231.8 | 46.2 | 185.6 | 27.6 | 113.8 | 59.9 |
| Flood control . . . | 260.5 | 55.4 | 205.0 | 30.4 | 125.3 | 180.7 |
| Energy . . . . . . | 513.8 | 230.8 | 283.0 | 42.0 | 173.1 | 403.9 |
| Total . . . . . . | 1 006.1 | 332.4 | 673.6 | 100.0 | 412.2 | 744.5 |

[a] Round figures.

[b] The percentages in this column are calculated as follows: in the case of navigation, the alternative justifiable balance (185.6) is divided among the sum of all the alternative justifiable balances. The quotient expressed in percentages is 27.6. The other two are calculated in the same manner.

[c] The percentages of the previous column are applied to the total (412.2) of this column in order to obtain the break-down. Thus, the value 113.8 is 27.6 per cent of 412.2.

mission, and the project was submitted to the consideration of the International Bank of Reconstruction and Development for its financing. It forms part of a much broader electrical programme and therefore its evaluation took place within this general framework, as will be seen later on. The power station belongs to a private enterprise but the credit requested would have a government guarantee.[13]

The project relates to the installation of a thermoelectric plant located close to the city of São Paulo. The plant would have two 80 000 kW generators, with hydrogen-cooling and driven by steam turbines with condensation. The general design of the plant follows the principle of a boiler for each turbo-generator group. The boilers are semi-covered type. Steam operation was selected—at 850 pounds per square inch (psi)— and a temperature of 925° F, conditions which are considered conservative.[14]

The boilers could burn pulverized coal or oil; the former could be used in a national emergency by adding certain auxiliary equipment. The installation of two oil tanks at the plant site is included, with a capacity of 140 000 barrels each, this being sufficient fuel for 7 weeks' operation at full load. The oil will be supplied through the Santos-São Paulo pipeline.

Each generating unit will be connected to a group of 3 transformers of 40 000 kW each. The low-tension control panel is the totally enclosed type and will be located in the main building. The equipment for the high-tension control panel will be placed in an open space adjacent to the main building. The plant will be connected to the primary system by two short lines at 88 000 volts. At five points and at suitable pressures, steam will be extracted to heat the feed water to a temperature of some 400°F.

Table 80 indicates the amount of the investments. The exchange rate used was 18.82 cruzeiros to the dollar.

[13] The plant belongs to the Brazilian Light and Traction Company, of Canada. Through the courtesy of this company and of the International Bank, it has been possible to include in this example, in addition to the data pertaining to the project, some of the operating results obtained.

[14] If it operated as a base plant, at higher temperatures and pressures, some 10 per cent of the fuel could be saved. But as this is in fact a thermoelectric reserve plant in a predominantly hydroelectric system, the choice was made in accordance with good practice.

Table 80

CASE 35. INVESTMENT IN A 160 000-KW THERMO-ELECTRIC POWER STATION

*(Thousands of cruzeiros)*

| | *Foreign exchange component of the investment (Equivalent in dollars)* | *National currency component* |
|---|---|---|
| Land . . . . . . . . . . . . . . . . . . . . | 15 | 35 000 |
| Building . . . . . . . . . . . . . . . . . . | 240 | 54 289 |
| Boilers . . . . . . . . . . . . . . . . . . . | 6 104 | 55 465 |
| Turbo-generators . . . . . . . . . . . . . . | 6 801 | 62 456 |
| Auxiliary electrical equipment . . . . . . . . . | 1 144 | 19 118 |
| Step-up transformers and control panel . . . . . | 1 210 | 10 000 |
| Transmission installation . . . . . . . . . . . | 565 | 23 956 |
| Construction equipment . . . . . . . . . . . . | 150 | 7 000 |
| Water circulation system for condenser . . . . . . | 379 | 2 492 |
| Temporary building . . . . . . . . . . . . . . | 50 | 5 620 |
| Contingencies . . . . . . . . . . . . . . . . | 2 228 | 40 404 |
| Total . . . . . . . . . . . . . . . . . . | 18 786 | 316 325 |
| Total cost . . . . . . . . . . . . . . . . | | 669 877 |

The estimates are based on firm orders and on the construction costs at the time of the study.

In this case, the justification for the project lay in the technical alternative selected, rather than on the decision to set aside resources to produce electricity. In fact, there was no special market problem because electricity was rationed. The annual growth of electric energy consumption in the region has been 11.2 per cent and it is estimated that the new installed capacity will, in the best of cases, cover the demand existing when it enters into operation. The new plant will add 35 per cent to the installed capacity at the inauguration date. The justification for the thermal solution is based fundamentally on the lesser time required for entry into operation of this type of power station and the speedy relief it will afford in the present situation of electric energy shortage in the zone. If the hydroelectric capacity of the system increases, the plant will be a thermal reserve unit for peak loads and will ensure the supply of the general system, which is now predominantly hydroelectric.

In fact, according to the programme, the company's installed capacity ought to treble by 1960, reaching 1.5 million kW. Except for the plant in question and its future expansions, most of the new capacity will be hydroelectric. A long period of drought, which is always possible, would bring with it serious economic losses to the industrial city of São Paulo if it depended entirely on hydroelectric energy.[15] It is assumed that normally the thermal plant under consideration will constitute a future reserve unit in the event of a long drought. Nevertheless, in view of the existing electric energy deficit and the upward trend of consumption, it is very unlikely that a sufficiently large expansion programme will be carried out in the near future to meet all the foreseen demand. In view of this, the plant analysed would have to operate at the beginning as a base load plant, which means importing petroleum and burdening the balance of payments.[16] This negative balance-of-payments effect would be considerably weakened in the future if the plant should act solely as a reserve unit.

The approximate present costs of thermoelectric generating at different load factors are shown in table 81.

An automatic increase in electricity rates is legally authorized when new thermal plants enter into operation. This covers the enterprise against possible increases in operating costs. In the case of the São Paulo system, the greater thermoelectric generating costs are charged on all sales by means of periodical adjustments of the rate. These increases are in fact a form of insurance which must be paid against the risk of drought or other eventualities. The sales cost of thermoelectric energy in 1955 was almost 0.55 cruzeiros per kWh, as against an average cost of all sales of 0.48 cruzeiros per kWh.

[15] The importance of this steam plant was confirmed during the droughts of 1954 and 1955, when the hydroelectric plants were short of water.

[16] In 1955 the plant used 402 314 tons of oil, which had to be imported.

**Table 81**

CASE 35. APPROXIMATE COSTS OF THERMAL GENERATION OF ELECTRICITY, 1956

*(Cruzeiros)*

| *Annual load factor (Percentage)* | *Cost per kWh*[a] |
|---|---|
| 40 | 0.40 |
| 60 | 0.33 |
| 80 | 0.30 |
| 100 | 0.28 |

[a] Excluding distribution and the enterprise's overheads but including depreciation and 5 per cent interest of costs.

## Chapter VI

# BUDGET OF INCOME AND EXPENDITURE AND ARRANGEMENT OF BASIC DATA FOR EVALUATION

## I. Introduction

The contents of previous chapters have provided the basic information necessary for judging the advantages of a project; the present chapter will explain the most common methods of arranging and summarizing these data as a preliminary step toward evaluation of the project. The primary calculation to be made is that of the yearly income and expenditure resulting from the realization of the project, and may be presented in the form of a two-column balance sheet entitled "Estimated budget of income and expenditure". On the basis of such a budget it is easy to calculate the volume of annual profits, unit costs, ratio of sales to costs and any other significant figures or coefficients. The detailed information for an estimate of each budget item can also be summarized and set out in the form of partial budgets for labour, raw materials and other materials, energy, etc., thus facilitating a comparison of the requirements of each item with the resources available. Similarly, a separate estimate can be made for those items directly affecting the balance of payments, and a partial budget can be drawn up for income and expenditure expressed in terms of foreign exchange.

Both the annual global budget of income and expenditure and the partial annual budgets will be subject to variation during the project's useful life, because of (*a*) possible price fluctuations and (*b*) the different percentages of production capacity really utilized.

Since an assessment of the project's advantages and drawbacks should cover its total useful life, a new budget should, strictly speaking, be prepared for each year of existence. Since this is impossible because of the difficulty of predicting the future, it is advisable to prepare annual budgets to cover those periods during which no fundamental changes are anticipated. In other words, a sufficient number of budgets must be drawn up to cover all possible important changes. For example, it may be estimated that an enterprise will respond to demand by working for a certain number of years at 50 per cent of capacity, another period of years at 75 per cent, and the remainder of its lifespan at 100 per cent of capacity. Three distinct budgets will therefore have to be calculated in accordance with the variation in utilized capacity. Likewise, predictable modifications in sales prices or in certain substantial input factors should be taken into account, such as the future availability of a fresh source of raw materials or electric power at prices differing from those actually in force.

To sum up, each annual budget will be valid for a certain number of years during which it is assumed that no important changes will take place. It often happens that an enterprise operates on the basis of a single budget which is considered to be representative for its entire lifespan.

An analysis of the influence exercised upon the budget by the above mentioned variations can be simplified by the use of graphs to determine the so-called break-even points.[1]

[1] I.e., points where income equals expenditure.

## II. Production expenditure or costs

Production expenditure or costs are calculated by means of an allocation of prices to the different resources required, whose physical volume has been quantified in accordance with the engineering studies. This chapter will do no more than deal with an evaluation in terms of market prices, pointing out in pertinent cases any information that may prove useful or necessary for social evaluation along the lines of the explanation given in Part Two.

Before a project's production costs can be estimated and presented, they must first be broken down into partial items in a similar, though not identical, manner to that employed for accounting purposes by enterprises already in operation. In the latter case, cost accounting has the dual purpose of recording everything that has taken place, and facilitating procedures for ensuring efficient administration of the enterprise, a function which has no part to play in a project. Here, specified technical and administrative output levels are accepted as fixed data, in conformity with the explanation provided earlier.[2] For this reason, the divisions and sub-divisions normally made in the cost accounting of an enterprise are not relevant, since they are designed to pinpoint defects in administrative and technical control. Nevertheless, the general structure of cost accounting can be employed for the aims of a project study, since it can be universally used to determine production costs, and enables useful information to be obtained from operating enterprises that resemble those projected. Plans for estimating project costs are less detailed than those needed for an enterprise in action, and data in them are grouped according to their evaluative role.

The type of classification and sub-division of items in the budget of production costs will vary according to the nature of the project, and will generally be adapted to the technique of the latter.

In budgets of industrial costs, a distinction is usually drawn between direct costs (related to the actual production process) and indirect costs (auxiliary services). Sometimes this distinction is applied only to the labour component, reference being made to direct and indirect labour. Maintenance and repair costs are often separated too.

In cost accounting, such divisions, as has already been explained, are designed to ensure the smooth functioning of the enterprise. There are many texts dealing with this subject. In budgeting a project, such divisions may be useful for simplified estimates of production costs. If the

[2] See chapter III.

experience of many plants shows that the cost of indirect labour (strictly defined in each case) represents, say, 30 per cent of direct labour, a careful estimate of the latter will indicate also the former.

Often the main budget items are computed and percentages applied to them to obtain the others. Such percentages should represent not only a simple empirical relationship but also a functional reality. However, they should be applied cautiously because the functional relationship may vary from one country to another and even from one place to another, particularly if they are expressed as monetary and not physical values.

This subject will be treated here in its broader lines only, leaving explanations of a more specialized character to the illustrative cases. The items may be grouped as follows: (*a*) raw materials; (*b*) other materials; (*c*) energy and fuels; (*d*) labour (employees and workers); (*e*) taxes, insurance and rent; (*f*) sales costs; (*g*) depreciation and obsolescence; (*h*) depletion of natural resources; (*i*) interest; and (*j*) unforeseen and miscellaneous.

### 1. *Raw materials and other materials*

Raw materials constitute an item of considerable importance in projects related to manufacturing, since this is basically a transforming activity. In projects concerned with crop and livestock production, seeds and fertilizers occupy a position similar to that of raw materials in manufacturing projects. "Other materials" refer to non-primary materials (or correspond to raw materials in non-manufacturing projects) and usually have little influence on production costs.[3] Outstanding examples would be lubricants, cleaning and preservative materials and spare parts in general. The insecticides and weedkillers included in crop and livestock projects could be listed under this heading. In the final tabulation of costs, it will be sufficient to show the necessary physical volumes and the unit prices placed on site. Additional details on stocks, future resources available, transport problems, etc. should be shown separately. In the case of imported products, the f.o.b. and c.i.f. costs should be indicated as well as the foreign exchange used, the place of origin, form and duration of transport, disembarkation port, customs duties, freight costs within the country, commission charges, storage and transshipment costs, and an estimation of possible shrinkages, losses of weight and other damages not covered by insurance. In the case of domestic products, any pertinent information of a similar type should be included. Estimates of possible future prices shared be justified. For purposes of social evaluation, details should also be given of other indirect taxes (apart from customs duties) that are imposed on materials in general, together with any information that might be of assistance in calculating opportunity costs.[4]

### 2. *Energy and fuels*

Costs of energy and fuels represent purchases of electric power, coal, fuel oil, paraffin, diesel oil, petrol or gas. If energy resources such as coal or oil are used, the costs will include transport and other charges similar to those already mentioned in connexion with raw materials.

The particular type of electric power used will raise special problems of supplies, transport, connexions and rates. The technical details have been discussed in the chapter on project engineering, but they will be summarized here from the point of view of physical volume and pricing.

### 3. *Labour*

This category comprises all personnel from the highest echelons down to non-skilled workers. Staff requirements may be set out in a systematic manpower budget in accordance with the project's technical and administrative needs, enumerating the qualifications and training required, daily wages and salaries, shifts, working hours and other information of this type. It frequently happens that foreign personnel have to be hired and retained for a certain length of time while potential national employees and workers undergo training. In such a case, the foreign currency costs should be indicated as well as the type of exchange used in calculating the expenditure, length of employment of such staff and other relevant details.

In order to justify the relative daily wages estimated, reference must be made to current rates of pay, and to all legal and other provisions which have a bearing on the cost and utilization of manpower. The daily wages paid in similar or neighbouring industries will often serve as a basis of estimation. The manpower item should include all those payments which derive from social regulations, family allowances, vacations, overtime, work on official holidays, night work, etc. These costs are occasionally estimated globally, by adding a certain percentage to the round sum of the nominal daily wages. But, in any case, it would be advisable to make a detailed calculation at least once, with a break-down of all the extra charges that may be anticipated, particularly if there are numerous legal regulations in existence, and the enterprise involves night work or work on official holidays. The omission of certain items of this kind may lead to serious errors when manpower occupies a high proportion of the costs.

In so far as market prices for manpower are concerned, it is best to depend upon the criterion of over—rather than under—estimation. It is highly probable that during the lifespan of the enterprise the daily wages will rise, provided that the country develops economically and income distribution does not decline. Moreover, the trained personnel required are usually taken from other enterprises, and are not willing to abandon their current work without a promise of higher payment. It is likewise inadvisable to underestimate the number of employees. Such under-estimations nearly always result when the experience of other factories with higher efficiency and productivity is taken as a basis. It may also prove necessary to install administrative offices near to the central authorities of the country, province or state, with whom continuous contact has to be maintained for the negotiation of import or export licences, credit problems, tariffs, etc. Such contact is often necessary in under-developed countries, owing to, *inter alia,* slow administrative processing and poor communication systems. The upkeep of these offices is often considerably more than the initial costs foreseen. It is useful to bear all these factors in mind from the start, or at least to set by a substantial amount under the heading of "unforeseen" to cover them.

[3] The qualitative difference between both categories consists in the fact that raw materials are a physical component—either totally or partially—of the production item, whatever the transformation process employed (for instance, the sodium in common salt is present in the caustic soda which originates from it), whereas "other materials" are not included physically in the product.

[4] These refer to market costs, adjusted in conformity with the norms laid down in Part Two, chapter I.

Finally, it would be of advantage to compile information on average wages in other activities; customary or projected employment levels in the zone; manpower mobility; and other factors which may be necessary for an evaluation of manpower in terms of opportunity costs.

### 4. *Insurance, taxes and rent*

This item is self-explanatory and requires no further detailing here. The cost of insurance can be obtained directly from any enterprise in this field, on the basis of estimates of fixed and inventory investments.

The taxes referred to in this item will include those on property owned by the enterprise, and indirect taxes connected with production.[5] Income tax is not included among production costs.[6] It would be helpful to compile and enumerate in an annex the total number of taxes which, under one heading or another, will have a bearing upon the future enterprise; such a list would also serve to indicate what contributions it will have to make toward public revenue, under the existing tax structure.

If the project is one of import substitution, it should be indicated that the freed exchange will allow imports of other goods which will probably pay higher customs duties and be in greater demand, thus increasing fiscal revenue. In actual fact, in view of the limited import capacity of under-developed countries, they are often obliged to resort to import controls of one kind or another so as to allocate foreign exchange in accordance with fixed priorities. If the project is devised to substitute imports or increase exports, the substituted imports may belong to categories hitherto shelved and hence of lower priority, which are customarily subject to higher customs tariffs than those on the products replaced. A favourable fiscal balance is thus obtained. This type of background data has no influence upon the project's direct budget of income and expenditure, but forms part of the additional information which facilitates a more accurante appraisal of its advantages and disadvantages.

### 5. *Sales costs*

Sales costs should be estimated in conformity with the prevailing market conditions for the product under consideration. If the project does not take into account any sales organization, this expenditure can be calculated as a global percentage of the value of the product. (For example, it may be supposed that the entire output passes to one general distributor, who is granted a certain discount.) It should be remembered that the introduction of a new product into the people's consumption habits—such as frozen meat, or artificial fibres produced domestically instead of the corresponding imported product—requires large-scale production and publicity campaigns, to which special consideration will have to be given in order to secure an accurate idea of the cost involved in a conquest of the market. The data collected in the market study will help in estimating this item.

### 6. *Unforeseen and sundry items*

The item "insurance" covers specific risks (fire, etc.), but there are certain fortuitous and completely unforeseeable circumstances which represent non-insurable risks. These, together with the fact that the project calculations cannot be infallible, are sufficient reason for the inclusion of an extra item entitled "unforeseen and sundry items", precisely to cover such contingencies and inaccuracies. In general, it is calculated as between 5 and 10 per cent of total costs.

### 7. *Depreciation and obsolescence*

In the course of time, renewable and tangible assets, such as machinery or buildings, undergo a loss in value attributable to physical or economic reasons. This diminution of value caused by physical deterioration or wear and tear through usage is what constitutes depreciation, whereas loss in value for economic reasons is denominated obsolescence. In general, these economic causes are a normal consequence of progress in the arts and sciences. For example, the invention of new methods of production or the perfectioning of certain machines may lead to the replacement of superseded or antiquated machinery by more recent models, in spite of the fact that the former was in good condition from a physical point of view. This explains why equipment is reduced in value with time, and this state of loss in entitled obsolescence to differentiate from that arising from physical wear and tear.

In practice, both concepts are merged in the expression "depreciation and obsolescence", or simply depreciation. Physical depreciation is naturally closely linked with economic considerations, since the significance of the term "physical lifespan" of equipment is that the machinery or other installations will function, not until the moment when deterioration or wear and tear make them physically useless, but until the cost of their conservation or repair becomes so high that their utilization is no longer economic. As to obsolescence, a renewable tangible asset may be said to have reached this state when its employment is no longer economic; in other words, there are concepts which are common to both depreciation and obsolescence, and relate to the economic usage of the assets in question.

The concept of the useful life of a renewable tangible asset is thus governed by the above considerations and takes simultaneous account of physical wear and tear and economic obsolescence. The cost item for depreciation and obsolescence, or simply for depreciation, should be added annually to the remaining production costs as a reminder that the useful life of such assets is limited. Some account may also be taken of the asset's residual value at the moment when it is discarded. The procedure for doing so is simple: the asset's scrap value is subtracted from its value as subject to depreciation, and only the difference is taken into account.

In estimating depreciation for the budget there are two aspects to be considered: what may be termed the physical input of capital goods in the production process, and the

[5] For example, the sales tax upon certain raw and other materials.

[6] For purposes of financing, and in order to demonstrate that the enterprise is in a position to service specified debts, it is desirable to make a separate estimate, in which income tax contributions have been deducted from the firm's income. By this means, it is possible to know the financial situation of the enterprise after all expenses, including those corresponding to the above tax, have been paid. However, such contributions will not figure in any budget drawn up for evaluation purposes. If the income taxes constitute a fixed percentage of the profits, it is a matter of indifference—for purposes of comparison—whether or not they are computed, but if, for instance, they are progressive, they can markedly affect the project evaluation. This would also occur if the income tax rate varied according to the type of activity.

additional costs which such input represents. This latter aspect is related in turn with the need to conserve the initial assets of the enterprise. In other words, an unspecified portion of the fixed renewable capital is transformed into current input in order to produce, together with the other input factors, different goods and services; it is hence necessary to decide the depreciation costs of this input. The part played by depreciation of equipment, machinery and buildings thus resembles that of "other materials" and not of raw materials. On the one hand, therefore, there is the economic transformation of fixed initial capital into other goods and services, and, as a balancing entry in the accounts, a margin of depreciation implying the conversion of initial capital into other assets. In this respect, the accounting process occupies two stages: in the first, a certain part of their value is deducted from the initial assets and, in the second, these values are regrouped to form parallel assets; the former diminish as the latter increase until the sum of both is equivalent to the original investment, in accordance with the basic premise that the initial assets should not be reduced. The practical problem of calculating depreciation costs consists in computing the transformation of fixed capital into other assets, which counterbalances the transformation of initial assets into goods and services produced by the project.[7]

The formation of "other assets" does not mean that the depreciation reserves are necessarily for other investments distinct from those in process of depreciation. In the case of manufacturing industries, such reserves are usually assigned to replace obsolete equipment, whereas, in that of mines or forest exploitations, they cannot be re-invested in the same form owing to the depletion of the natural resources. Thus, the establishment of parallel assets indicates no more than the formation of reserves equivalent to the depreciated assets with a view to retaining the initial capital intact. These reserves are finally destined for a separate project, which may or may not deal with the same type of activity. This concept is of importance in relation to the problems of interest and profitability which will be discussed later on.[8]

The methods of calculating depreciation most frequently mentioned in textbooks are: (*a*) that of linear depreciation; (*b*) the cumulative method based on a sinking fund; (*c*) that of the decreasing surplus; and (*d*) that based on the annual units produced. For project preparation, the first two only are of any basic interest. The method most commonly used both for projects and in the accounting practices of enterprises is that of linear depreciation.

(a) *Linear depreciation*

In linear calculations, the volume of investment in the form of renewable fixed assets (machinery, buildings, etc.) is divided by the number of years of life assigned to them, and the result is added to the annual production costs. Assuming an investment of 10 000 dollars, with a lifespan of 10 years, and without residual value, the annual linear depreciation to be added to the costs would be 1 000 dollars. Estimating the residual value as 1 000 dollars, the annual depreciation would be 900 dollars. The difference between this method and that based on the sinking fund is that the former makes no assumption whatsoever as to the destination of the reserve. It is important to remember this, as it will help to clarify the fact that the differences between the linear and sinking fund methods are more apparent than real in so far as the profitability estimates of the project are concerned.

(b) *Sinking fund*

This method assumes that a fixed quota at compound interest will be deposited at the end of each year, so as to ensure that a sum equal to the original investment will have been accumulated at the expiry of the period of the period of usefulness anticipated for the renewable asset. The amount of amortization per annum is obtained by multiplying the volume of the original investment by what is known as the "sinking fund factor", resulting in the formula:

$$\text{Sinking fund factor} = \frac{i}{(1 + i)^n - 1}$$

where 1 is the original investment, "i" the rate of interest at which the fund accumulates, and "n" the lifespan of the asset in years.[9] The value of this factor has been calculated in financial tables for various periods and at various rates of interest.

It is important to have a clear understanding of how depreciation reserves are formed in order to be able to compute the initial investment value at the termination of the lifespan. The amount added yearly to such reserves equals the fixed quota forming the sinking fund plus the interest accumulated on the fund up to the year in question. Consequently, the annual contribution to the fund is not identical but increases every year. For instance, in calculating the annual depreciation cost for a project whose renewable assets are valued at 10 000 dollars with a lifespan of 10 years, and whose sinking fund has an interest rate of 4 per cent, the sinking fund factor given in the tables is 0.08329, signifying that the annual quota for the fund will be 832.90 dollars for 10 years. If the annual depreciation cost—forming the depreciation reserves—were no more than this, the amount would not exceed 8 329 dollars at the end of the 10-year period. However, the reserves are constituted by adding the quota for the fund to the interest accumulated on it, i.e. in the present case, by adding 4 per cent per annum up to the year in question. Thus, at the end of the first year, the depreciation cost is equal to the quota, or 833 dollars (in rounded figures). At the end of the second year, it is 833 plus 33 dollars' interest (4 per cent of 833 dollars). The reserves built up at the end of the second year are therefore 1 699 dollars (833 dollars for the first and second years respectively, plus 33 per cent interest on the first year's total). During the third year they will earn 68 dollars interest, which, added to the annual quota of 833, will increase the reserve fund by 901 dollars. Thus, at the end of the third year, it will stand at 2 600 dollars.

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[7] The problem of depreciation possesses complications that are not relevant for consideration here. For example, the provision of financial coverage for recuperating initial capital does not assure the replacement of the depreciated physical installations, since, apart from price fluctuations, there are the factors of technical innovation and functional changes in the use of depreciated equipment to be taken into account, viz. the case of a locomotive transferred from main lines, to branch lines and thence to shunting work.

[8] See sub-section 8.

[9] "I" is expressed quantitatively as so much per unit and not as so much per cent. If the annual rate of interest is 6 per cent, "i" would be 0.06.

It is very important to remember that the annual contribution to the sinking fund does not constitute the annual depreciation cost in its entirety, and that the reserves are supplemented by the yearly addition of 4 per cent interest. In other words, the reserves have been "set to work" to obtain a certain annual interest which is used to increase their amount, if no other use is indicated for it by the linear depreciation method.

At first sight, it would appear that larger profits are calculated by the sinking fund method than by the linear method. For instance, in the case of 10 000 dollars capital with a 10-year lifespan, the gross annual profits (without discounting depreciation) would be 1 500 dollars. By the linear depreciation method, however, net profits would be computed at 500 dollars, since 1 000 dollars have to be subtracted annually. In contrast, when the sinking fund method is used, 833 dollars have to be subtracted annually, plus the total interest on the reserve fund. However, as it is assumed that this interest is charged on the reserves themselves, the project's net profits are not reduced, and would thus be 667 dollars per annum, or greater than those calculated by the method of linear depreciation. It is obvious that the same project cannot have real profits that rise or fall according to whichever accounting criterion is used, but, as mentioned previously, the difference derives from the fact that in the one case no assumption is made as to the future employment of the reserves, whereas in the other they are assigned to a specific destination according to which they will acquire 4-per-cent profit. Theoretically speaking, differing net profits can be obtained according to the rate of profitability assumed for the reserves, but, as the sinking fund is only an accounting fiction, the rate of interest agreed upon is always moderate.

Basically, the problem may be summed up as follows: when the sinking fund method is used, it is accepted that the whole of the initial capital remains in movement. While the part still undepreciated operates to produce goods and services as required by the project, the depreciated share is converted into liquid assets with a fixed rate of interest. When the linear method is used, the destination of the reserves is unspecified, and the only fact known is that the assets still undepreciated diminish as the profitability increases.

The linear method is widely preferred for its simplicity, and because it does not involve any assumptions as to the rate of interest on the cumulative fund, but, for purposes of comparison between projects, either of the two methods is suitable. If the sinking fund method is chosen, however, the same rate of interest should be applied in all projects under comparison.

### (c) *Other methods*

The decreasing surplus method consists in adding a fixed percentage of the non-depreciated surplus to the overall depreciation costs. The costs are high during the first few years but become lower in the course of time. The annual quota is variable, and residual value must exist before the method can be applied. On the other hand, the method based upon units of production presupposes a depreciation cost which is proportional to annual output and hence varies in accordance with it. When output is uniform, the linear method is automatically used. Neither of the first two methods described is applicable for the purposes of a project study.

### (d) *Depreciation period*

Any calculation of the amortization period will be arbitrary in the extreme, owing to the fact that not only must in the probable physical life of the equipment, buildings and installations be taken into account, but also their probable economic life, which is fundamentally influenced by innovations and technical factors, as well as by local conditions of economic development. These latter relate not only to the differences existing between under-developed countries and large industrialized centres, but also to those between "old" and "new" industrialized countries.[10]

The physical lifespan of equipment is not governed by purely technical concepts, but may be considerably prolonged if higher maintenace and repair costs are accepted. Information on the average life of equipment, and factory installations as a whole, may be found in specialized textbooks and engineering manuals. Some data are included here for purposes of illustration, on equipment frequently used in chemical industries (see tables V, and VI).

The different conservation and replacement policies that may be adopted have their particular influence on the useful life of the equipment. Strictly speaking, there is a relationship between the estimated costs for maintenance

[10] See, for example "Obsolescence and Technological Change in a Maturing Economy", by Marvin Frankel, *The American Economic Review*, Vol. XLV, No. 3, June 1955, pp. 296 *et seq.*

**Table V**

ESTIMATED AVERAGE LIFE OF EQUIPMENT

| *Equipment* | *Years* | *Equipment* | *Years* |
|---|---|---|---|
| Boilers | 25 | Kilns | 22 |
| Brick and steel buildings | 33 | Mills | 12 |
| Compressors | 20 | Mixers | 12 |
| Condensers | 17 | Motors | 14 |
| Coolers | 17 | Pipes | 15 |
| Crushers | 12 | Pumps | 20 |
| Dryers | 25 | Retorts | 22 |
| Electric furnaces | 20 | Screens | 12 |
| Evaporators | 17 | Tanks | 20 |
| Filter presses | 17 | Thickeners | 5 |
| Gas furnaces | 8 | Transformers | 15 |

*Source*: Robert S. Aries and Robert D. Newton, *Chemical engineering cost estimation*, New York, McGraw-Hill Book Co., 1955.
*Note*: This table has been reproduced by kind permission of the publishers.

**Table VI**

AVERAGE LIFE BY PLANT

| *Type of plant* | *Years* | *Type of plant* | *Years* |
|---|---|---|---|
| Acids | 15 | Electrochemical | 17 |
| Alkaline products | 22 | Oxygen production | 18 |
| Aniline dyes | 20 | Pharmaceutical | 20 |
| Atmospheric nitrogen | 15 | Pulp | 17 |
| Carbide and carbon products | 15 | Refinery | 25 |
| Coal-tar products | 21 | Soap | 20 |

*Source*: As for table V.
*Note*: In spite of the durations given in the table, the text recommends a cost estimate on the base of 10 or 20-year periods in order to take obsolescence into account.

and for depreciation but, except in very special cases, an explicit analysis or calculation of this relationship is not justified.

The problem of depreciation also has its legal aspects which are connected with the regulations of national internal revenue offices. Such regulations usually define the exact amortization periods for different assets.[11] The legal duration may differ considerably from that accepted in actual fact, since amortization rates are occasionally used as an incentive to promote the development of certain activities. The net result is an upwards distortion in costs in exchange for lower income tax; any such arbitrary features should be eliminated before attempting a comparison between projects.

To sum up, an estimate of the amortization period involves certain unavoidable subjective estimates. On the basis of data provided by technical publications on the useful life of equipment, estimates may be made and then adjusted to conform to prevailing conditions and the criteria of the planners. As a general rule, it is accepted that periods of usefulness from both the physical and economic standpoints are of longer duration in under-developed countries than in industrial centres, but that the cost item for maintenance is heavier in the former. On the other hand, the safety margin can be reduced to offset any possible underestimations.

### 8. *Depletion of natural resources*

Certain projects dealing with primary production (mines, for example) are based on the exploitation of a natural resource that cannot be replenished. Consequently, an item covering the depletion of the resources in question must be included in the costs, the amount specified depending on the value of the depleted assets and the duration of the exploitation.

### 9. *Interest*

An analysis of a series of projects demonstrates that the item for interest is not given the same emphasis in one cost budget as in another, the differences being motivated as much by the aims of the calculations as by the project-maker's individual judgment.

In some cases, the criterion employed in the project is identical to that adopted in the accounting ledgers of an operating enterprise, i.e., an item for interest is included only for the specific amount incurred for actual long—or short—term credits. No entry is made in the ledgers for "interest imputed" on equity capital, but only for that actually paid.[12] Given definite financial conditions for the project, the interest to be paid is calculated in accordance with them. This criterion is nevertheless inadequate since it is clear that the intrinsic advantages of a project cannot be assessed in terms of the financial provisions made.[13]

An objective comparison of projects obviously requires all income and expenditure budgets to be calculated on the same bases. With regard to interest, there are two simple ways of levelling out the conditions: one, to include interest on the whole of the capital involved, and the other, to eliminate any consideration of interest. A suitable compromise between these alternatives is to include an item for interest in the costs to demonstrate the need for the project to yield a return on its capital as well as on the other production factors. The amounts invested represent advance returns on capital input during the life of the project; they imply a differentiation between the use of certain resources, and require a calculation of the corresponding interest. Hence, together with the cost of amortization, account must be taken of the interest on capital tied up in renewable assets. As the capital is reduced in time by depreciation, the costs for interest also diminish. When calculating depreciation costs and interest jointly, two of the formulae most frequently used will give the same amount per annum. One of these formulae follows a strict method of calculation based on the sinking fund already referred to, while the other follows a method approximating to that of linear depreciation.

The first formula is as follows:

$$\text{c.r.f.} = \frac{i}{(1+i)^n - 1} + i \qquad (1)$$

where c.r.f.—the "capital recovery factor"—represents the coefficient by which the investment to be recovered is mul-

[11] The United States Treasury Department considers amortization to be a "reasonable" allocation to compensate for depletion, wear and tear and deterioration, including obsolescence, of the capital goods owned by a business or industry, and thus to permit a computation of the loss of value undergone by such goods upon becoming obsolete. See United States Treasury Department, Bureau of Internal Revenue, *Income tax depreciation and obsolescence. Estimated useful lives and depreciation rates,* Washington, D. C., January 1942.

[12] See chapter VII, section II, 3, b, relating to the advantages and disadvantages of financing a project by means of credits, and its effect upon profits and income tax.

[13] However, the financial mechanism may affect the evaluation and priority order in special cases, as, for example, when there is a possibility of obtaining foreign credit for a specific type of project only. The granting of long-term credits at low rates of interest may serve as one of the mechanisms permitting projects with high social priority to attract private capital as well, but in such a case, the amount of interest that the enterprise carrying out the project has to pay will not influence the evaluation but will have been adjusted *a posteriori* so as to ensure that the project is sufficiently attractive to private enterprise, or to solve the financial problems of a State-owned enterprise.

tiplied in order to obtain the annual cost for depreciation and interest; "I" is the original investment, "i" the rate of interest and "n" the number of years or periods. It may be realized that this factor is the sum of the *sinking fund* factor and the rate of interest. The formula assumes that the rate of interest at which the sinking fund is built up is the same as that on the capital employed.[14] If the original value subject to depreciation is multiplied by the c.r.f. factor—which may be obtained from financial tables—the annual cost of depreciation and interest on fixed capital will result. To take an example: the capital recovery factor, at 5 per cent interest, for 20 years, is 0.08024. If the capital to be recovered (renewable assets) is 10 000 dollars, the annual cost for depreciation and interest will be 802 dollars. This implies that if 802 dollars per annum are set aside each year and invested at 5 per cent interest, at the end of 20 years the 10 000 dollars will be recovered and will have yielded during the whole of that time an annual return of 5 per cent. It may therefore be said that the annual quota of 802 dollars represents the "equivalent annual cost" of the capital subject to depreciation.

The second method is based upon a linear calculation of depreciation, and interest is charged upon non-depreciated value at the rate agreed upon. The formula for this method is:

$$(2) \qquad (\text{c.r.f.}) = \frac{1}{n} + \frac{i\,(n+1)}{2n}$$

in which "i" is again the interest rate and "n" the number of years. When the interest rates are not very high and the periods not very long, both methods give similar results. Using the same data as before, the annual cost of depreciation and interest would be 760 dollars per annum under the second method.[15]

Incidentally an error that is often committed in calculating depreciation and interest costs, is to add the annual linear depreciation cost to the interest on *total* capital. This latter method ignores the fact that the renewable assets are reduced in the course of time to the extent that they constitute depreciation reserves.[16]

The foregoing considerations may be summarized as follows: (*a*) the income and expenditure budget relates to the operation of the future production unit during one year; as the fixed renewable capital is invested once only at the beginning of the enterprise's operations, it is essential, in order to calculate the annual budget, to convert the invested sum into equivalent annual costs, since it is depreciated physically and economically in time; (*b*) the conversion described in (*a*) should take into account the fact that such investment presupposes different utilization of the resources; actually, it signifies the inclusion in the cost of a certain sum of interest; (*c*) there are two methods of calculating the annual equivalent cost; by means of an equivalence formula which takes into account the influence of compound interest; and by the insertion of an item equalling the total arrived at by linear depreciation (fixed investment divided by the number of years of useful life) plus the average annual cost of interest. The latter formula represents an approximate method, and, because it is simple and avoids any derivations and interpretations related to the "sinking fund", it is often used for calculating income and expenditure budgets.

[14] This formula should be kept in mind since it is used to calculate the servicing of a debt on a long-term basis. A more detailed explanation is given with reference to financial equivalents (Part Two, chapter II, annex).

[15] In the formula, "n" is 20 and "i" is 0.05. Therefore the c.r.f. is 0.076 which, multiplied by 10 000 dollars, gives 760 dollars.

[16] For a comparison of profitability between projects, the figures for gross profits may be used without including depreciation or interest in the costs, and the "equivalent rates of interest" compared. See Part Two, chapter III.

## III. Income

The project's income derives from the volume of production and the selling prices of the goods and services produced. The volume of production is dependent on the size of the project, as defined in the relevant chapter,[17] and on the percentage of installed capacity utilized. Given a certain size—and provided that prices do not fluctuate—income will vary according to this percentage or, which amounts to the same thing according to the production volume.

Prices will be those estimated in the market study. If the normal output volume is not sufficiently large for its variations to affect the market price of the commodity or service considered, the volume of income, for a given production figure, will be directly proportionate to the prices.

[17] See Part One, chapter IV.

## IV. Other important data for the evaluation

### 1. *Cost equation*

The need to analyse any modifications which would occur in the budget as a result of variations in any of its outstanding items, during certain stages of the project's lifespan, has already been pointed out. This analysis would facilitate an appreciation of the entrepreneur's safety margins necessary to counteract such variations, and is more easily carried out with the use of graphs to show the budget and the so-called break-even points.

The problem under review can be defined by asking the following questions: What variations will take place in the budget and unit cost of production if there are changes in the percentage of installed capacity utilized? What is the minimum percentage below which the enterprise would suffer losses?

To carry out this type of analysis, it is advisable to divide the costs into two large groups only: one comprising costs that are proportional to the output volume, and the other, those unaffected by it. For instance, property taxes are constant, whatever the annual output attained, and depreciation and interest are also independent of the production cycle. In contrast, items such as raw materials, and the manpower actually employed, are normally proportionate to the volume of output. Fixed costs and variables can be represented in simple graphs by making the abscissae represent the percentages of installed capacity in use[18] and the ordinates—the fixed and variable costs. Since the fixed costs will be the same whatever the utilized capacity, they will form a line parallel to the axis of the abscissae. Assuming the variable costs to be in direct proportion to production volume, they will be represented by a straight line passing through the point of departure and sloped in accordance with the unit cost. The costs function will be given by the equation: $C = Vx + F$, in which $C$ is the total annual cost, $V$ the variable unit cost, $F$ the fixed total annual cost and $x$ the percentage of normal production capacity utilized, or the volume of annual production. In order to plot the costs line on the graph, it will thus be sufficient to know two points on it. In the case of an output volume equal to zero, the total cost is reduced to the cost of $F$, which has to be calculated in any case. Subsequently, if the cost of 100 per cent normal production capacity is estimated, this will give a second point enabling the line AD to be plotted on the graph (see figure IV).

The total annual costs are not necessarily a linear function of output volume. There are certain cost items which are neither strictly in proportion to the capacity utilized nor completely constant, and, consequently after adding all the items, it will be found that the costs do not vary in linear form. With reference to the linear formula given above, this may be expressed by saying that $V$, the unit cost of inputs, is not necessarily constant.

For example, empirical studies show that the labour costs per unit of production in the steel or brick making industries diminish as the utilized capacity of the plant increases.[19] If there are specific data of this kind, which may be used for the project, an equation may be worked out reflecting the cost variations more accurately than the linear method.

However, in many cases, it will not be possible or necessary to introduce such refinements into the project study, either because there are no such data applicable to the project or because the other data available for the analysis are not sufficiently accurate to justify them.

Generally speaking, the greater the proportion of fixed costs in total costs the more accurate will be the estimate of linear variation, because the former, by definition, have a linear variation, often, an approximation resulting from a classification of the fixed and variable costs.

### 2. *The budget in graph form*

In the same graph showing fixed, variable and total annual costs, a straight line (OR in figure IV) can be drawn, to pass through the point of origin of the diagram, and represent annual income for different rates of production, assuming the sales price to be constant. In this way, the project's income and expenditure may be plotted on the graph for different percentages of installed capacity utilized. The abscissae may equally well represent this percentage, the production value in monetary units (pesos in the graph) or the physical volume of production measured in units suitable to the commodity produced. The units represented by the abscissae will vary according to the type of project and the goods produced. In the case of a single commodity such as sugar, any one of the units mentioned is suitable for use, but when several types of goods are produced, they may sometimes be reduced to a common physical unit, as, for instance, tons of steel in an iron steel industry, in which case the abscissae will represent the physical volume of production. In this case, too, an average selling price for the different steel products will have to be estimated, and income value will be obtained by multiplying the average price of the physical unit employed by production volume. If the manufactured products are so heterogeneous as to hamper their reduction to physical units, the use of a monetary unit as a common denominator is warranted, the sales value at different levels of utilized capacity being represented by the abscissa. This latter system is applicable in all cases.

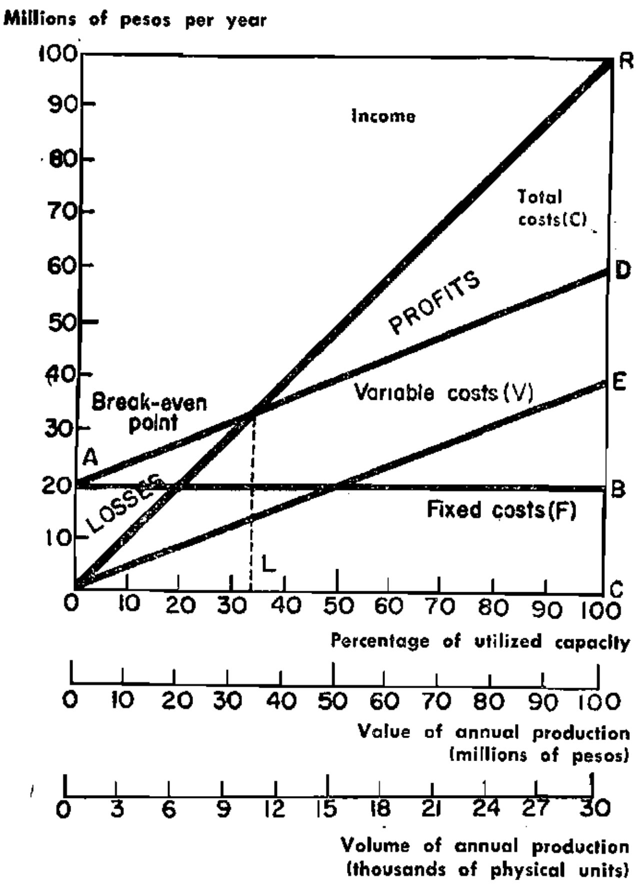
Income and costs are expressed in monetary units in the ordinates. In figure IV, the fixed annual costs represented by the line OA are 20 million units, and the line AB, which represents these costs for various rates of production, is parallel to the axis of the abscissae. The variable annual

[18] Or any equivalent unit of measurement, such as the number of units produced under different rates of production.

**Figure IV**

COSTS AND INCOME AT DIFFERENT VOLUMES OF UTILIZED PRODUCTION CAPACITY

NATURAL SCALE




[19] See, for example, the following studies prepared jointly by the Trade and Agriculture Departments of the United States: *Manufacturing Brick and Tile,* Industrial (Small Business) Series No. 49, U.S. Government Printing Office, Washington, 1946; *Will making concrete block pay in your community?,* Industrial (Small Business) Series No. 23, U.S. Government Printing Office, Washington, 1945. The latter is the source of case 41 which illustrates this chapter.

costs at full production capacity, would be 40 million and are represented by the line CE on the graph. The total costs of 60 million are represented by CD. Since the variable costs have been assumed to be in strict proportion to capacity utilized, the lines OE and AD represent the respective modifications in the variable and total costs in conformity with the disparate production cycles.

### 3. *Break-even points*

The graph distinguishes clearly between the zones of profits and loss for the project, and the break-even point i.e., the rhythm of operation required for the enterprise to preserve a state of equilibrium in which it neither gains nor loses. The break-even point can also be determined in relation to the prices of the input factors and commodities concerned in the project. Thus, in figure IV, the intersection of the lines OR and AD gives a break-even point corresponding to a utilization percentage L of installed production capacity (approximately 35 per cent). However if, in addition to assuming the utilized production capacity to be variable, prices are made to vary, other break-even points can be obtained which will contribute to a sounder appraisal of the enterprise's operating conditions. For instance, in order to estimate the influence of a modification in selling prices, a series of income lines would correspond to one line for total costs, and a calculation in graph form could be made of the minimum production level to be maintained by the enterprise without its sustaining losses for each of the assumed sales prices.

In this way, through an analysis of the break-even points, the zones of utilized capacity can be estimated together with the limits of variation of other key factors within which the enterprise may operate most successfully. This is of primary importance for the projects if they are to circumvent the difficulties inherent in a projection of demand and prices, which require the provision of a certain safety margin.

To sum up briefly, the break-even points help to establish and delimit the probable danger zones for the operation of the enterprise in so far as the factors of price variation and utilized capacity are concerned. The method of procedure is illustrated by the following examples.

#### (a) *With income variations*

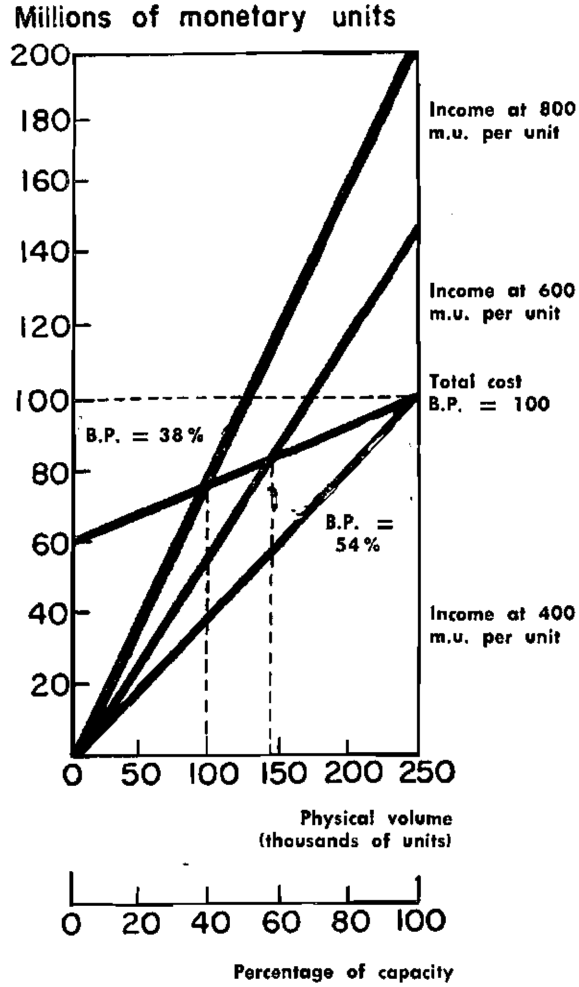
A project to exploit a mine which will produce for export, at a normal production level of 250 000 units per annum, may be taken as an example. If there is a multiple exchange system for exports, the selling price per unit may be 400, 600 and 800 monetary units (m.u.), depending on whichever exchange rate is in force. It is also assumed that the fixed and variable costs are 60 and 40 million monetary units respectively per annum, when the mine is working at normal capacity.

These data are shown in figure V, in which three break-even points have been determined corresponding to the three prices indicated above, always assuming that the other factors are unchanged. The graph demonstrates that at an exchange rate which fixes the sales price per unit at 400 m.u., the break-even point is only attained at 100 per cent utilized capacity, or, at best, the enterprise's income and expenditure will do no more than balance one another. Inversely, under an exchange rate favouring a rise in the selling price per unit to 600 m.u., the break-even point would be at 54 per cent of normal capacity and, at 800 m.u. the unit, 38 per cent of normal capacity.

**Figure V**

BREAK-EVEN POINTS WITH VARIABLE SELLING PRIC

NATURAL SCALE




*Note*: B.P. stands for break-even point.

#### (b) *With cost variations*

In figure VI, selling prices are constant, and an analysis has been made of two fixed (75 and 50) and two variable cost estimates.

In cases "A" and "B", the variable costs are the same, but the fixed annual costs are respectively 75 and 50. Break-even points are obtained at 76 per cent of capacity in the case of "A", and 52 per cent in the case of "B".

In "C" and "D", in which the variable costs equal one another but differ from those in "A" and "B", the break-even points are reached at 52 and 36 per cent of installed capacity. It may be noted that in both "B" and "C", the break-even point is reached at the same percentage of capacity utilized, because the greater fixed costs of "C" in relation to "B" are counterbalanced by the lower variable costs.

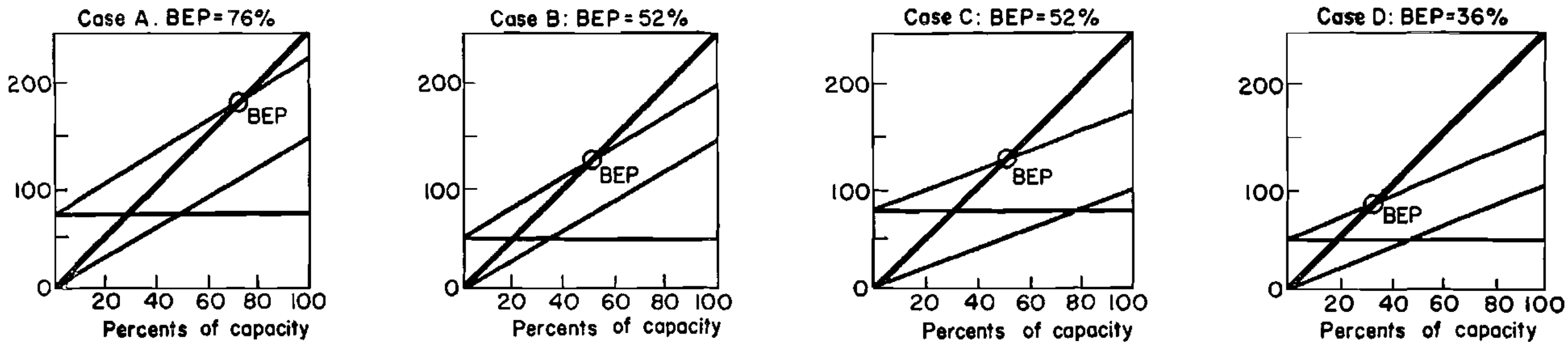
#### (c) *With simultaneous income and price variations*

Figure VII represents a case in which the variable costs and prices are assumed to fluctuate, and only the fixed costs—10 million monetary units—indicated by OA remain

**Figure VI**

BREAK-EVEN POINTS WITH A CONSTANT SELLING PRICE AND ALTERNATIVE FIXED AND VARIABLE COSTS

NATURAL SCALE




**Case A**

| *Percentage of utilized capacity* | *Selling price* | *Fixed costs* | *Variable costs* | *Total cost* | *Profit or loss* |
|---|---|---|---|---|---|
| 20 | 50 | 75 | 30 | 105 | 55 |
| 40 | 100 | 75 | 60 | 135 | 35 |
| 60 | 150 | 75 | 90 | 165 | 15 |
| 80 | 200 | 75 | 120 | 195 | 5 |
| 100 | 250 | 75 | 150 | 225 | 25 |

**Case B**

| *Fixed costs* | *Variable costs* | *Total cost* | *Profit or loss* |
|---|---|---|---|
| 50 | 30 | 80 | 30 |
| 50 | 60 | 110 | 10 |
| 50 | 90 | 140 | 10 |
| 50 | 120 | 170 | 30 |
| 50 | 150 | 200 | 50 |

**Case C**

| *Percentage of utilized capacity* | *Selling price* | *Fixed costs* | *Variable costs* | *Total cost* | *Profit or loss* |
|---|---|---|---|---|---|
| 20 | 50 | 75 | 20 | 95 | 45 |
| 40 | 100 | 75 | 40 | 115 | 15 |
| 60 | 150 | 75 | 60 | 135 | 15 |
| 80 | 200 | 75 | 80 | 155 | 45 |
| 100 | 250 | 75 | 100 | 175 | 75 |

**Case D**

| *Fixed costs* | *Variable costs* | *Total cost* | *Profit or loss* |
|---|---|---|---|
| 50 | 20 | 70 | 20 |
| 50 | 40 | 90 | 10 |
| 50 | 60 | 110 | 40 |
| 50 | 80 | 130 | 70 |
| 50 | 100 | 150 | 100 |

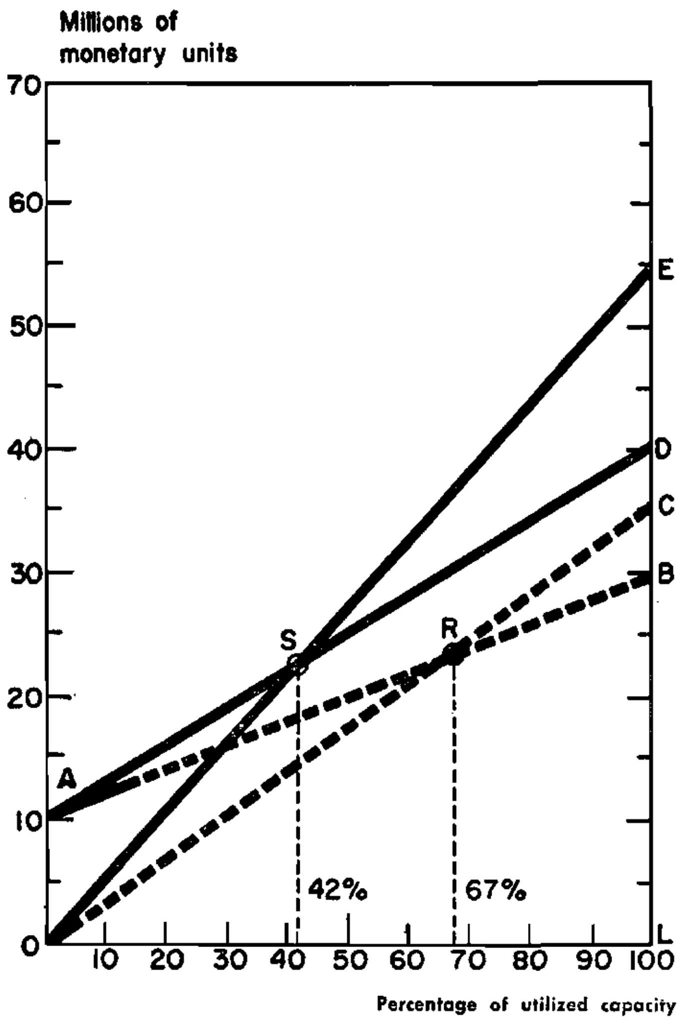
constant. In the first alternative analysed, total costs at 100 per cent of capacity are 30 million m.u. yearly (LB in the graph) and income at the same percentage of capacity is 35 million m.u. (LC). The break-even point R is obtained at 67 per cent utilized capacity.

In the second alternative, a price variation is assumed which will affect income and costs to a different degree. At full capacity, costs will rise from 30 to 40 million m.u., or 33 per cent (LD), and income will increase from 35 to 55 million, or practically 60 per cent (LE). The break-even point is thus reached at 42 per cent of installed capacity utilized.

**Figure VII**

BREAK-EVEN POINT WITH INCOME AND PRICE VARIATIONS

NATURAL SCALE




## V. UNIT COSTS

### 1. *The unit costs equation*

In every project it is important to know the production cost per unit of product, since the possible profit to be obtained from the latter is derived from a comparison of the unit cost with the current or anticipated selling price. Moreover, a comparison of the unit cost of production for the project with the costs of other entrepreneurs —or, failing this, the actual profit margin per unit according to the project—will offer the entrepreneur a measure of his competitive potential.

The unit cost will naturally vary in accordance with the percentage of capacity utilized, and will decrease as the latter approximates to the normal capacity estimated for the project. The line reflecting this decrease will be a curve whose general equation may be determined from that of total costs.

The linear equation for total annual costs is:

(1) $$C = VX + F$$

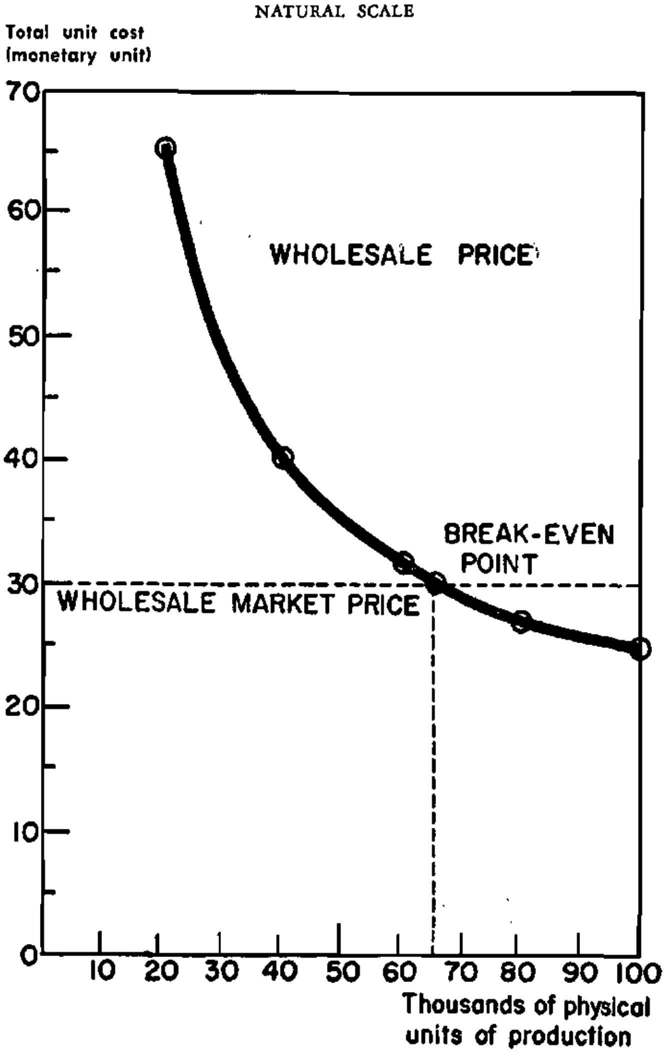
in which X represents physical production per annum fluctuating in accordance with utilized capacity, and F the total fixed annual costs. If the whole equation is divided by X, the following will result:

(2) $$\frac{C}{X} = V + \frac{F}{X}$$ If $\frac{C}{X} = C'$, the result will be

Figure VIII

DETERMINATION OF PRODUCTION VOLUME TO OBTAIN MINIMUM RETURNS INVESTED ON CAPITAL

NATURAL SCALE




(3) $C' = V + \frac{F}{X}$ which is the equation of a hyperbole.

In equation (2), the first term represents the total unit cost of production. In the second term, V is the variable cost per unit of production, which, by definition, is assumed to be constant. Conversely, the total fixed annual costs (F) become variable when computed per unit of production. In brief, the terms are inverted between equations (1) and (3)—the variable annual costs becoming constant per unit of product, and the fixed annual costs becoming variable per unit.[20] If the equation of total annual costs were not linear, the unit costs curve would not be obtained from equation (3) but from a separate calculation based on the annual costs for different percentages of production.

2. *Break-even points in a unit costs graph*

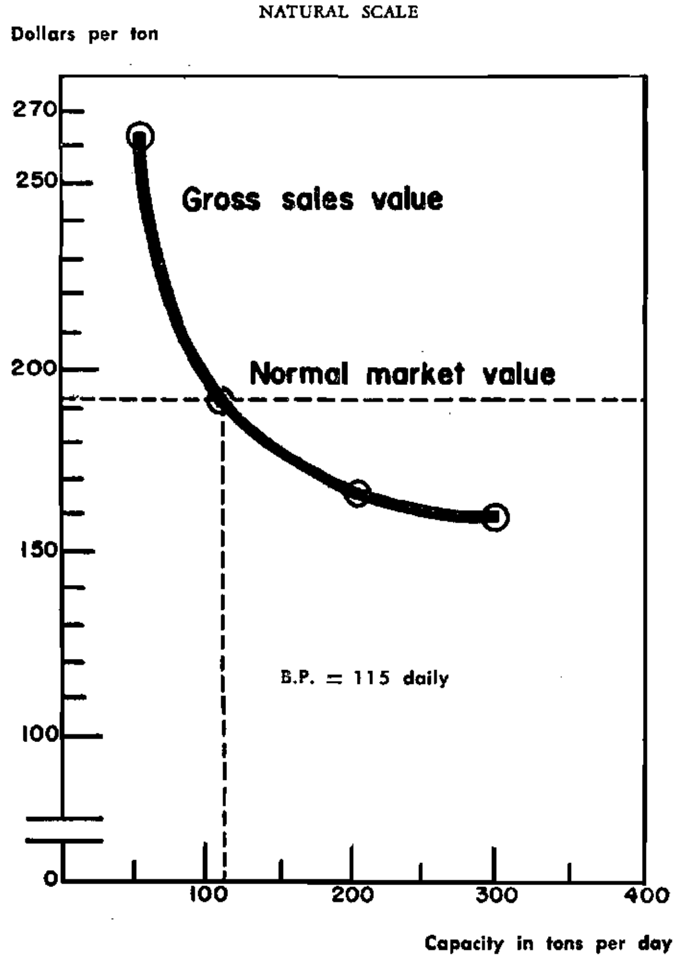
The concepts relating to break-even points are also applicable to an analysis of unit costs, which will be compared with unit prices on the market. Equation (3) may be depicted in graph form (figure VIII) the abscissa representing production volume (or percentage of utilized capacity) and the ordinates representing unit cost.

The various criteria adopted for calculating the costs of certain items result in different unit costs, two of the variations being worthy of special comment. One of these relates to the inclusion or exclusion of selling costs and, in general, to a review of the distribution problem, while the other concerns the inclusion or exclusion of a cost item to cover a minimum return on invested capital, at an agreed rate of interest. With regard to the first, it is obvious that the unit cost will have to be compared with the market price for the same distribution stage. If the cost has taken into consideration selling prices up to and inclusive of wholesale distribution, the wholesale market price will also have to be included in the comparison. The second criterion involves a special calculation of the profitable factors in the project under study, and hence, among other elements, that of the corresponding risk and current rates of interest on the local market. When capital returns are included in the costs, what may be termed an estimate of the "gross sales value" is obtained, i.e., the price at which the goods or services under considerations must be sold in order to cover costs and provide a satisfactory return on capital invested. The following case, in which

Figure IX

BREAK-EVEN POINT BETWEEN GROSS SALES VALUE AND NORMAL MARKET VALUE IN TERMS OF THE PRODUCTION SCALE

NATURAL SCALE




[20] In equation (1), VX is the *annual* variable cost; V the constant *unit* cost; and X the variable amount of production.

the values are expressed in hypothetical monetary units, may be taken as an example:

| | |
|---|---|
| (*a*) Wholesale fixed annual production cost, including satisfactory returns on employed capital | 1 000 000 |
| (*b*) Variable unit cost | 15 |
| (*c*) Physical units produced at full normal capacity | 1 000 000 |
| (*d*) Wholesale market price per unit of product | 30 |

On the basis of these data, it may be determined what annual volume of production is necessary to yield the minimum satisfactory returns referred to in (*a*).

Equation (3) becomes:

$$c' = 15 + \frac{1\ 000\ 000}{x}$$

x being the number of units produced per annum.

If values of 20 000, 40 000, 60 000, 80 000 and 100 000 are respectively assigned to the variable *x*, the following series of values will be obtained for unit cost $c'$:

| *Annual production in thousands of units* | *Total unit cost* |
|---|---|
| 20 | 65.0 |
| 40 | 40.0 |
| 60 | 31.6 |
| 80 | 27.5 |
| 100 | 25.0 |

These values may be used for plotting a curve of wholesale prices varying in accordance with production. By plotting on the same graph a straight line for the wholesale market price, the break-even point corresponding to 65 000 physical units of annual production may be obtained (figure VIII).

### 3. *Analysis of break-even points to help determine size of the project*

The method for determining break-even points may also be helpful in analysing the problem of size. The abscissae represent the different sizes to be considered, taking for granted in each case that the enterprise will be operating at normal capacity. The ordinates will stand for costs and income, whether as annual totals or per unit, the costs including minimum returns on invested capital. The break-even point thus obtained for income and expenditure will point to the minimum size at which the project may be economically remunerative. The case depicted in figure IX is that of a project study for pulp and newsprint.

## Illustrative cases

### *Case 36*

#### Presentation of the income and expenditure budget in a sugar-mill project

This example refers to the same project previously used to illustrate investments.[1]

The manufacturing costs estimates were divided into three groups: sugar, dried cossettes, and alcohol, since the project in fact included all three activities. The molasses is used to make alcohol, and the cossettes—the residual beet pulp, after extraction of the sugar—are dried in a special installation. Wet pulp and molasses could be sold, but, for reasons explained in the project, it was preferred to include the installations for distilling alcohol and for drying the cossettes; thus in the costs budget the coal for making sugar appears as an item separate from the coal required to dry the cossettes. Depreciation and obsolescence charges were calculated in cumulative terms, assuming 6 per cent annual interest for the sinking fund; interest on capital was not charged to costs, and the calculation of net return was made in gross terms (see table 82).

In the presentation of the balance sheet (table 83), special note should be taken of the item "foreign exchange rate subsidy", which has been added to income because it is related to the problem of pricing the factors, dealt with in Part Two. In the present case, it is included because the income calculation was made on the basis of sales at the official market price for refined sugar, produced in the country from imported raw sugar.[2] Raw sugar was imported at 31 pesos per dollar, which was an obviously preferential exchange rate; the free dollar at that time stood at 100 pesos, and certain authoritative estimates placed the true value at 85 pesos.

This 31 pesos rate was so obviously preferential that in the calculations of the project's investments the dollars for imported equipment were taken at the alternative official exchange rate of 60 pesos. Under these conditions, it was apparent that the domestic sugar could not compete in price with the imported sugar, which enjoyed such a high subsidy. To equalize conditions, the project adopted the artifice of assuming that for each "substitution dollar"—that is each dollar which the project would free for other purposes—a state subsidy of 29 pesos would be received (the difference between 60 and 31, the two official rates). The volume of "freed exchange" was considered to be equal to the c.i.f. cost of the raw sugar required to produce 10 000 tons of refined sugar, the capacity of the projected plant. For each dollar of this c.i.f. cost, the state would grant, through preferential exchange rates, a subsidy of 29 pesos, or 3 578 pesos per ton of refined sugar. It was pointed out that the addition of this sum to income would not involve any additional burden on the national budget, but only a transfer within that budget: the dollars allocated for the import of sugar "freed" by the project, would be sold at 60 pesos instead of 31, and the difference of 29 would become a subsidy for the domestic enterprise.

It was also argued in the project that if the subsidy on imported sugar were withdrawn, there would be a price increase on the domestic market of at least the amount of the subsidy, so that the calculations of the estimated budget would not change as regards profits. The income from the subsidy would disappear, but the selling prices would be increased by the same amount.

Finally, a separation has been made in table 83, between the cost of labour for seasonal workers and the permanent staff. This is because the industry only works for 100 days

[1] Case 29.

[2] The projected plant was the first in the country to work with domestic raw material.

Table 82

CASE 36. PRODUCTION COSTS OF SUGAR, ALCOHOL AND DRY COSSETTES (FROM 800 TONS OF SUGAR BEET)

*(Pesos)*

| | Annual cost | | Cost per ton of sugar |
|---|---|---|---|
| | Partial | Sub-total | |
| I. *Sugar beet* | | | 9 692.3 |
| 1. Placed at farm | 68 000 000 | | |
| 2. Freights | 12 000 000 | 80 000 000 | |
| II. *Sugar manufacture* | | | 4 193.5 |
| 1. *Manufacture* | | | |
| (*a*) Seasonal workers | 3 300 352 | | |
| (*b*) Coal | 4 680 000 | | |
| (*c*) Lime | 1 423 760 | | |
| (*d*) Coke | 511 680 | | |
| (*e*) Other materials | 1 551 680 | | |
| (*f*) Packing | 1 872 000 | | |
| (*g*) Reception and handling | 2 844 000 | 16 183 472 | |
| 2. *General expenses* | | | |
| (*a*) Permanent employees and workers | 15 164 463 | | |
| (*b*) Repair materials and miscellaneous items | 5 000 000 | | |
| (*c*) Insurance | 3 300 000 | 23 464 463 | |
| 3. *Contingencies* | 3 964 480 | 3 964 480 | |
| III. *Dry cossettes* | | | 328.5 |
| 1. Coal | 2 810 080 | | |
| 2. Packing | 341 120 | | |
| 3. Contingencies | 265 200 | 3 416 400 | |
| IV. *Alcohol* | 3 418 480 | 3 418 480 | 328.7 |
| V. *Depreciation* | 3 216 000 | 3 216 000 | 309.2 |
| *Totals* | *133 663 295* | *133 663 295* | *12 852.2* |

Table 83

CASE 36. SUMMARY OF THE PRESENTATION FOR CALCULATING INCOME AND THE BALANCE SHEET

*(Pesos)*

| A. *Annual income* | | |
|---|---|---|
| I. Sale of sugar | | 114 400 000 |
| II. Sale of dry cossettes | | 6 832 800 |
| III. Sale of alcohol | | 12 897 040 |
| Total income | | *134 129 840* |
| B. *Balance sheet* | *Totals* | *Per ton of sugar produced* |
| Income | 134 129 840 | 12 897.1 |
| Expenditure | 133 663 295 | 12 852.2 |
| Credit balance | 466 545 | 44.9 |
| Foreign exchange rate subsidy | 39 087 360 | 3 758.4 |
| Gross profit | 39 553 905 | 3 803.3 |

in the year, during which seasonal unskilled labour is contracted.

## *Case 37*

### Calculation of income and expenditure budget and of net return in a metallic zinc-making project

#### 1. *Table of final presentation*

This is the same project as that used for explanations of technical processes and calculations of investments.[3] The criteria adopted and the method of presentation for calculating the income and expenditure budget and the net return are summarized in table 84.

It should be noted in the first place that when estimating the volume of annual income, the calculation was made for four different prices of zinc bars, which were considered to be most probable according to a mathematical-statistical analysis of past trends. Some details are given later of this projection of prices, both for zinc and fertilizer. Income is simply the result of multiplying annual production by the projected price.

It may be seen that costs are summarized in three items: costs of zinc concentrates, amortization and interest, and operating costs according to the details given. A "provision for taxes" has been subtracted from profits, calculated as the difference between income and costs, so that net profit after taxes can be obtained. Finally, net return was calculated on the basis of net profits—after taxes—and with respect to total capital, including working capital.

Some details of the partial items are given below, beginning with selling prices and income.

#### 2. *Projection of selling prices for calculation of income*

(a) *Zinc*

During the past 50 years—the project was made in 1950—the price of zinc varied very greatly, ranging from a maximum of 27 cents per pound during the first world war to a minimum of 2.5 cents in 1932. The study was made at the time of the highest post-war price (18.5 cents per pound). To estimate the profits, it was considered necessary to estimate the price of zinc over the next 20

[3] Cases 22 and 32.

**Table 84**

CASE 37. COSTS, INCOME, PROFITS AND RETURN

*(Dollars)*

| | Zinc prices[a] (Cents per pound) | | | |
|---|---|---|---|---|
| | 5.0 | 6.8 | 8.4 | 10.5 |
| A. *Income*[b] | 6 832 000 | 8 404 000 | 9 612 000 | 11 329 000 |
| Zinc[c] | 2 902 000 | 4 474 000 | 5 682 000 | 7 399 000 |
| Ammonium sulphate | 3 930 000 | 3 930 000 | 3 930 000 | 3 930 000 |
| B. *Costs* | 7 171 400 | 7 171 400 | 7 171 400 | 7 992 400 |
| 1. Zinc concentrates | 2 172 000 | 2 172 000 | 2 172 000 | 2 993 000 |
| 2. Amortization and interest[d] | | | | |
| (*a*) On investment in local currency[e] (20 years at 5 per cent) | 536 900 | 536 900 | 536 900 | 536 900 |
| (*b*) On the investment in dollars[e] (20 years at 4 per cent) | 1 166 500 | 1 166 500 | 1 166 500 | 1 166 500 |
| 3. Operating costs, as per detail[f] | 3 296 000 | 3 296 000 | 3 296 000 | 3 296 000 |
| C. *Profits* | — 239 400 | 1 232 600 | 2 440 600 | 3 336 600 |
| Provision for taxes (15 per cent of profits) | | 184 900 | 366 100 | 500 300 |
| D. *Profits after taxes* | — 239 400 | 1 047 700 | 2 074 500 | 2 836 300 |
| E. Net return (profits after taxes, divided by the total investment)[e] | | 4.6% | 9.2% | 12.6% |

[a] Most probable prices, according to a statistical study of historical series (see text: projection of prices).
[b] Total annual production capacity—zinc, 40 880 tons; ammonium sulphate, 98 185 tons.
[c] Less freight, insurance and customs duties in the purchasing country.
[d] Cumulative amortization and interest on total capital.
[e] The total investment is 22 544 million dollars, of which 6 690 cover the equivalent in national currency, and the remainder is in dollars.
[f] See table 86.

years, instead of being influenced by current conditions. The highest United States authorities on the subject were consulted. The conclusion was reached that, according to foreseeable future conditions, the price of zinc could be expected to maintain a level higher than that of the pre-war period. No significant decline in current prices could be foreseen, at least for some years. In spite of these forecasts, the price of zinc fell 50 per cent in less than a year. In view of this discouragement, it was decided to take into account not only future prospects, but an analysis based on past statistics. The mathematics department of a large United States university was requested to make an analysis of historical series in relation to the probable price of zinc. This mathematical technique had been reasonably successful in other studies. The results of the study were as follows:

(i) Assuming 20 years of peace, the most probable price would be 6.8 cents per pound, with a minimum of 5.0 and a maximum of 10.5 cents.

(ii) Assuming that in the first 20 years there were four years of war, the average value would probably be 8.4 per pound, with the same limits of 5.0 minimum and 8.5 maximum.

In short, four probable zinc prices for the next 20 years were obtained: 5.0, 6.8, 8.4 and 10.5 cents per pound, and it was decided to calculate the income and expenditure budgets on the basis of each of these four.

At the time when the mathematical study was completed, the price was 10 cents per pound, and the zinc experts were again consulted. They estimated that the market position of the metal was still strong, and that the price would probably show an increase in the next one or two years. This opinion was based on the rapid obsolescence of zinc refining by the retort method—50 per cent of the plants are of this type—which would mean that supply would increase less than the demand. It was noted that, although new uses for zinc would undoubtedly be found, possible substitution by aluminium, plastics and stainless steel should be borne in mind.

(b) *Ammonium sulphate*

The selling price of this product was estimated in relation to the cost of imported nitrate fertilizers which it would substitute. On this basis, a selling price of 40.00 dollars per ton was recommended for ammonium sulphate, plus distribution costs. This price compares very favourably with imported sulphate, the c.i.f. cost of which, less custom duties, was 102 dollars in 1948, and with natural nitrates, which was 65.75 dollars per ton in 1949, also excluding duties.

### 3. *Cost of concentrates and amortization charges*

Some detailed data are given below, to illustrate the methods used and the criteria adopted in calculating production costs.

(a) *Concentrates*

It was estimated that 238 tons of concentrates were required daily, of 86 870 tons annually.[4] The cost per ton was calculated by the formula used by United States smelters to determine the cost of imported zinc concentrates. According to this formula, the smelter pays 85 per cent of the zinc content of the concentrates, and discounts 50 dollars treatment costs per ton of concentrates when the price of zinc is 12 cents per pound. This cost varies by about 2 dollars for each cent of variation of the base price of the metal. The resulting price is understood to be f.a.s. New York or New Orleans, after payment of import taxes.

On this basis, and estimating that the concentrates will be 57.5 per cent zinc, the cost of concentrates would be that shown in table 85.

[4] Short tons of 2 000 pounds.

Table 85

CASE 37. CALCULATION OF COST OF CONCENTRATES

*(Dollars per ton)*

| | | |
|---|---|---|
| Cost per ton according to the United States smelters' formula (assuming a price of 0.10 dollars per pound) . . . . . . . . . . . (2 000 × 0.575 × 0.85 × 0.10) | | 97.75 |
| Less: treatment cost (50-4) . . . . . . . . | | 46.00 |
| Price f.a.s. New York . . . . . . . . . . . | | 51.75 |
| Less: United States customs taxes (0.0075 dollars per pound of metal in the concentrates) . . . . . . . . . . . . . . . . . . | 8.63 | |
| Freight to New York . . . . . . . . . . . | 11.60 | |
| Port charges, port of shipment . . . . . . . | 3.46 | |
| | 23.69 | 23.69 |
| Net price at domestic port of shipment . . . . | | 28.06 |
| Plus: Freight to the site under study for the zinc plant . . . . . . . . . . . . . . . | | 2.50 |
| | | 30.56 |

Using the above formula, and assuming that freight rates will not change, the cost of one ton of concentrates will vary by 7.77 dollars for each cent variation in the price of the metal. It is obvious that the formula cannot be applied systematically for any reduction in zinc prices, since if the cost of the concentrates becomes too low, the mines would cease to operate. With this in view, the project-makers applied the formula only for prices of 10 cents and over per pound. In the case of lower prices, it was assumed that the cost of concentrates for the plant should permit the mines to operate above their break-even point.[5] This minimum cost was estimated at 25.0 dollars per ton.

This is naturally an average estimate, since the supply comes from many small mines, but a cautious price was fixed to ensure sufficient incentive for the production of the mines.

### (b) *Amortization and interest*

The sinking fund method was used, but different amortization criteria were employed for the national currency investment and the purchases in foreign currency; the same period of 20 years was applied to both, but with 5 per cent interest for local expenses and 4 per cent on the remainder.

The total investment, including working capital, consists of: 6.69 million dollars, which would be spent as its equivalent in national currency, and 15 845 millions which will be spent in dollars. The capital recovery factors after 20 years with 4 and 5 per cent interest annually are 0.07358 and 0.08024 respectively. In this way the annual amortization and interest charges (in dollars) will be:[6]

6 690 000 x 0.08024 = 536 900 for the local investment
15 845 000 x 0.07358 = 1 166 500 for the dollar investment

## 4. *Calculation of operating costs*

The estimate of all annual production costs may be seen in table 86.

[5] Break-even points were explained in chapter VI, sections IV and V.

[6] Attention is called to the fact that amortization has been calculated on total capital, including working capital.

### (a) *Labour*

Continuous operation for 365 days of the year is assumed. The working week for the personnel would be six 8-hour days. The total number of men employed is therefore one-sixth greater than the number of man-days. An average wage of 4 dollars, including social contributions, was taken for all labour, excepting in the ammonia plant, where wages would average 6 dollars per man-shift.[7]

The composition of the workers is shown in table 87.

### (b) *Administration and supervision*

It is assumed that there will be 100 employees, including 30 engineers. Salaries would vary between 25 000 dollars per year for the general manager and 1 000 dollars for office workers. The engineering staff would be: 12 metallurgists, 12 for the ammonia process, 6 for the electrical system, boilers and the acid and sulphate plants. Foreign personnel would be employed at the beginning, to be replaced gradually by local employees.

### (c) *Miscellaneous inputs (excepting zinc concentrates)*

*Chemical products.* The principal chemical products required would be copper sulphate, an arsenic compound, and small quantities of sulphuric acid and ammonium chloride for the zinc plant. The ammonia plant requires caustic soda, copper compounds and acetic and formic acid.

*Coal.* This will only be used for the production of gas in the ammonia plant, since oil is cheaper for fuel. The daily coal consumption will be 84 tons (30 660 tons annually) at 7 dollars per ton.

*Fuel oil.* This will be used for drying the concentrates before the leached tailings and the ammonium sulphate are charged in the roaster. Annual requirements have been estimated at 11 682 tons (32.5 tons per day), and the unit cost at 6.00 dollars. The oil for the boilers has been charged under steam, which in turn appears under services.

*Paper bags.* Although most of the output would be shipped in bulk, and additional provision for bags was

[7] As seen in table 86, a difference is made between employees and workers, labour referring only to workers.

**Table 86**

CASE 37. ESTIMATE OF ANNUAL PRODUCTION COSTS

*(Thousands of dollars)*

| | *Zinc plant* | *Sulphuric acid plant* | *Ammonia plant* | *Ammonium sulphate plant* | *Total to produce ammonium sulphate* | *Grand total* |
|---|---|---|---|---|---|---|
| A. *Labour* | 267 | 108 | 288 | 47 | 443 | 710 |
| Direct workers | 197 | 73 | 157 | 38 | 268 | 465 |
| Maintenance and repair | 70 | 35 | 131 | 9 | 175 | 245 |
| B. *Salaries* | 170 | 26 | 173 | 12 | 211 | 381 |
| C. *Miscellaneous inputs* (excepting zinc concentrates): | 325 | 18 | 235 | 403 | 656 | 981 |
| Chemical products | 181 | – | 16 | – | 16 | 197 |
| Catalytic agents | – | – | 5 | – | 5 | 5 |
| Coal | – | – | 214 | – | 214 | 214 |
| Fuel Oil | 36 | – | | 35 | – | 71 |
| Bags | – | – | | 350 | – | 350 |
| Miscellaneous items (including tools) | 108 | 18 | [a] | 18 | 36 | 144 |
| D. *Spares* | 294 | 46 | 55 | 73 | 174 | 468 |
| E. *Services* | 442 | 20 | 279 | 9 | 308 | 750 |
| Electric energy | 364 | 16 | 60 | 7 | 83 | 447 |
| Steam | 66 | – | 203 | 2 | 205 | 271 |
| Water | 12 | 4 | 16 | | 20 | 32 |
| F. *Royalties* | – | 6 | – | – | – | 6 |
| G. *Grand total* | 1 498 | 224 | 1 030 | 544 | 1 798 | 3 296 |
| Daily production (tons) | 112 | 205 | 73 | 269 | | |
| Annual production (tons) | 40 888 | 74 825 | 26 645 | 98 185 | | |
| Cost per ton | 36.64 | 2.99 | 38.66 | 5.54 | 18.31[b] | |

[a] Included under spares.
[b] Total cost, packed (bulk cost would be 14.54 dollars).

**Table 87**

CASE 37. COMPOSITION OF LABOUR

| | *Number of workers* | |
|---|---|---|
| | *Total* | *Daily* |
| Operation | 330 | 283 |
| Maintenance | 197 | 169 |
| Specialists | 28 | 24 |
| *Total* | 555 | 476 |

included. The item could be reduced by the plant making its own bags.

*Miscellaneous.* Includes hand tools, filter cloth and protective clothing. The rubber surrounds for the cathodes are a large item, and could be of domestic manufacture.

(d) *Spares*

The main item will be replacement anodes and cathodes for the zinc plant, amounting to 90 000 tons per year. (The calculation includes the life of the material, and its residual value.)

(e) *Services*

*Process steam.* Steam costs have been estimated at 50 cents per 1 000 pounds. The heaviest consumption will be in the ammonia plant.

*Water.* The plant would require 1 250 gallons of fresh water per minute for normal operation. The chief use is for cooling.

*Electric energy.* The peak demand would be 17 000 kW for the electrolytic cells, and 3 100 kW for the remainder of the zinc plant. The peak power of the ammonia plant would be 4 500 kW, and 2 200 kW in the remaining plants. The availability of electric energy is one of the reasons leading to the study of the project.

*Royalties.* The roasting process is patented, and a royalty must be paid; it is included in the costs (item F of table 86).

*Case 38*

COMPARISON OF PRODUCTION COSTS BETWEEN A THERMAL AND A HYDRO-ELECTRIC POWER STATION

This example illustrates the structure of electricity production cost by means of hypothetical figures for a thermal and a hydro-electric power station of 50 000 kW capacity. The figures used are completely arbitrary, and should not be taken to illustrate any true case; they are only adopted to show the methods.

1. *Data*

It is assumed that the cost per kW of installed capacity is as shown in table 88.

The cost shown for the hydro-electric plant includes the increased cost of transmission lines and condensers, so as to equalize conditions with the thermal plant, which would, presumably, be closer to the consumer area. An average

Table 88

CASE 38. INVESTMENT COSTS PER INSTALLED KW

| | Cost per installed kW | | |
|---|---|---|---|
| | *Dollars* | *National monetary units*[a] | *Total in national monetary units*[b] |
| Thermal plant | 150 | 7 500 | 22 500 |
| Hydraulic plant | 80 | 25 000 | 32 000 |

[a] Includes customs duties at 30 monetary units per national import dollar.
[b] The exchange rate is assumed to be 100 national monetary units per dollar.

useful life of 25 years is taken for the thermal plant, and 40 for the hydraulic one.

Production costs are calculated on the basis of table 89. The equivalent annual cost of invested capital has been calculated by the cumulative formula with 8 per cent interest. If it were calculated by the approximation method (linear depreciations plus average interest), the following capital recovery factors would result (always at 8 per cent interest on residual capital): thermal plant, 8.16 per cent; hydraulic plant 6.6 per cent. The servicing of interest is consequently less than with the cumulative formula. The selected interest rate is conventional; for foreign loans it is somewhat high.

The personnel fixed expenses and others are essential annual expenses, regardless of the production rate. The same criterion applies to maintenance and miscellaneous costs which are considered apart from production.[8]

Operating expenses are not necessarily a function of capital, but for simplification purposes the former have been expressed as a percentage of the latter.

Coal is the most important of the variable operating expenses of the thermal plant. In the example, 0.7 kg of coal has been taken as the annual operating average per kWh, and the cost of coal as 1 200 monetary units per ton. If this gives 7 000 calories per kg, the thermal efficiency will be 4 900 calories per kWh. The case was also examined on the basis of using coal fines at 0.9 kg per kWh, at 600 monetary units per ton. If the fines gave 6 000 calories, per kg, the thermal efficiency would be 5 400 calories per kWh, and the cost per kWh would be 0.54 monetary units for fuel, and 0.79 as the variable total per kWh.

The acceptance of a uniform fuel cost per kWh implies a uniform thermal efficiency, even at different production rates, which is only an approximation. Nevertheless, if it is accepted, for instance, that fuel costs for the preparation of the equipment are charged to fixed costs, and there is more than one generating unit, each with a separate boiler, the approximation will serve for a preliminary estimate. Although in practice the fuel operating costs will vary according to the load, the estimated average may be sufficiently close to eliminate the need to study possible differences in a preliminary estimated calculation.

The cost of lubricants and other materials, excepting spares, is estimated at 10 per cent of coal costs. The remaining expenses for maintenance, additional labour, production, tax, etc., are considered to be proportional to the cost of coal (20 per cent). The production tax may be calculated separately in specific cases.

These three last items have not been taken into account in the hydraulic plant in table 89. The variable costs per kWh are much lower in this case, and have been combined with those of spares required for production, production tax and other costs, and arbitrarily fixed at 0.05 monetary units per kWh.

[8] The separation of fixed and variable maintanance expenses must be arbitrary in practice.

## 2. *Annual production costs per kW of installed capacity*

In order to obtain the total annual expenses per kW of installed capacity, the variable costs per kWh must be expressed in terms of annual costs per kW of installed capacity; the costs per kWh must therefore be multiplied by the expression:

Table 89

CASE 38. HYPOTHETICAL COST STRUCTURE

| | *Thermal plant* | | *Hydraulic plant* | |
|---|---|---|---|---|
| *Fixed capital expenses (percentages of total investment)* | | *11.37* | | *9.89* |
| Cumulative depreciation plus 8 per cent interest (capital recovery factor) | 9.37 | | 8.39 | |
| Insurance and taxes | 2.00 | | 1.50 | |
| *Fixed annual operating expenses (percentages of total investment)* | | *2.00* | | *2.00* |
| Personnel and others | 1.00 | | 1.00 | |
| Maintenance and miscellaneous | 1.00 | | 1.00 | |
| *Total fixed expenses (percentages)* | | *13.37* | | *11.89* |
| *Variable expenses (monetary units per kWh)* | | *1.09* | | *0.05* |
| Coal | 0.84 | | – | |
| Lubricants and others (10 per cent of the coal cost) | 0.08 | | – | |
| Other expenses for maintenance, additional operating labour, production tax, etc. (20 per cent of the coal cost) | 0.17 | | – | |
| Spares, lubricants and miscellaneous items in hydraulic plants, including production tax | – | | 0.05 | |

**Table 90**

CASE 38. PRODUCTION COSTS PER INSTALLED KW

*(Monetary units)*

| *Type of plant* | *Fixed cost* (A) | *Total cost*[a] (B) |
|---|---|---|
| With coal. . . . | 3 000[b] | 3 000 + 1.09 × (p.f.) × 8 760 |
| With coal fines. | 3 000[b] | 3 000 + 0.79 × (p.f.) × 8 760 |
| Hydraulic. . . . | 3 920[c] | 3 920 + 0.05 × (p.f.) × 8 760 |

[a] The fixed cost from column A has been added to the variable cost per kWh from table 89, multiplied by the expression (4) deduced earlier.
[b] 13.37 per cent of the investment per kW according to table 89.
[c] 11.89 per cent of the investment per kW according to table 89.

$$(1) \qquad \frac{\text{kWh per year}}{\text{kW installed}}$$

Expression 1 is a function of the plant factor (p.f.).[9] By definition,

$$(2) \qquad \text{p.f.} = \frac{\text{average demand}}{\text{installed capacity (kW)}}$$

The average demand is:

$$(3) \qquad \frac{\text{kWh per year}}{8\,760}$$

Combining (2) and (3),

$$(4) \qquad \frac{\text{kWh}}{\text{kW}} = (\text{p.f.})\ 8\,760$$

The fixed and total annual costs per kW installed are shown in table 90.

The expressions in column B of table 90 show the total annual production cost per kW installed as a linear function of the plant factor, that is, of the percentage of the capacity used. To plot this straight line graphically, it is sufficient to calculate any two points, as has been done in table 91.

Figure 4 can be made up from the figures in table 91.

[9] See technical appendix at the end of case 3 (Part One, chapter II).

**Table 91**

CASE 38. ANNUAL PRODUCTION COST PER INSTALLED KW AT 0% AND 100% LOAD

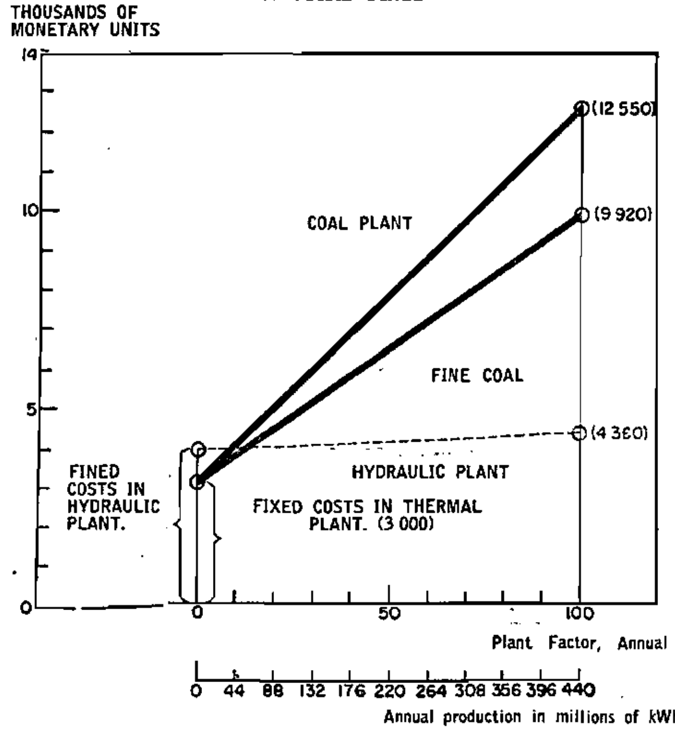
*(Monetary units)*

| *(p.f.) (Percentage)* | *Annual production (Millions of kWh)* | *Annual cost per installed kW* — *Thermal* — *Coal* | *Coal fines* | *Hydraulic* |
|---|---|---|---|---|
| 0 | 0 | 3 000 | 3 000 | 3 920 |
| 100 | 438 | 12 550 | 9 920 | 4 360 |

**Figure 4**

CASE 38. ANNUAL COST PER KW INSTALLED

NATURAL SCALE




The abscissa show either the annual plant factor or the number of kW produced in one year. The ordinates show the annual costs per installed kW in thousands of monetary units.

### 3. *Production costs per kWh*

To obtain total costs per kWh, the annual fixed costs must now be expressed in these terms, since the variable costs were estimated per kWh. The fixed annual production costs per installed kW must now be multiplied by the expression:

$$(5) \qquad \frac{\text{kW installed}}{\text{kWh produced}}$$

Expression (5) is the reciprocal of (4), that is:

$$(6) \qquad \frac{\text{kW}}{\text{kWh}} = \frac{1}{(\text{p.f.}).\ 8\,760}$$

If the fixed annual expenses per installed kW are multiplied by expression (6), the fixed costs per kWh produced are obtained; adding this to the variable costs per kWh, the total production cost per kWh is finally obtained[10] (see table 92).

[10] The annual fixed cost per installed kW is shown in column A of table 9.

**Table 92**

CASE 38. TOTAL COSTS PER KWH

| | |
|---|---|
| Thermal plant with coal. . . . . . . . . . . . | 1.09 + [3 000/(p.f.)] × 8 760 |
| Thermal plant with coal fines. . . . . . . . . | 0.79 + [3 000/(p.f.)] × 8 760 |
| Hydraulic plant. . . . . . . . . . . . . . . . | 0.05 + [3 920/(p.f.)] × 8 760 |

Table 93

CASE 38. VALUES OF THE HYPERBOLIC FUNCTION

| *(p. f.) (Percentage)* | *(p. f.) × 8 760* | *Total cost per kWh (monetary units, round figures)* | | |
|---|---|---|---|---|
| | | *Thermal plants* | | *Hydraulic plant* |
| | | *Coal* | *Coal fines* | |
| 10 . . . . | 876 | 4.51 | 4.22 | 4.53 |
| 20 . . . . | 1 752 | 2.80 | 2.50 | 2.28 |
| 30 . . . . | 2 628 | 2.23 | 1.93 | 1.54 |
| 50 . . . . | 4 380 | 1.78 | 1.48 | 0.95 |
| 70 . . . . | 6 132 | 1.58 | 1.28 | 0.69 |

The cost per kWh is a hyperbolic function of the plant factor. Values for 5 points are included, calculated as shown in table 93. These values are shown in figure 5 where the abscissae still represent the plant factor or the annual production in kW.

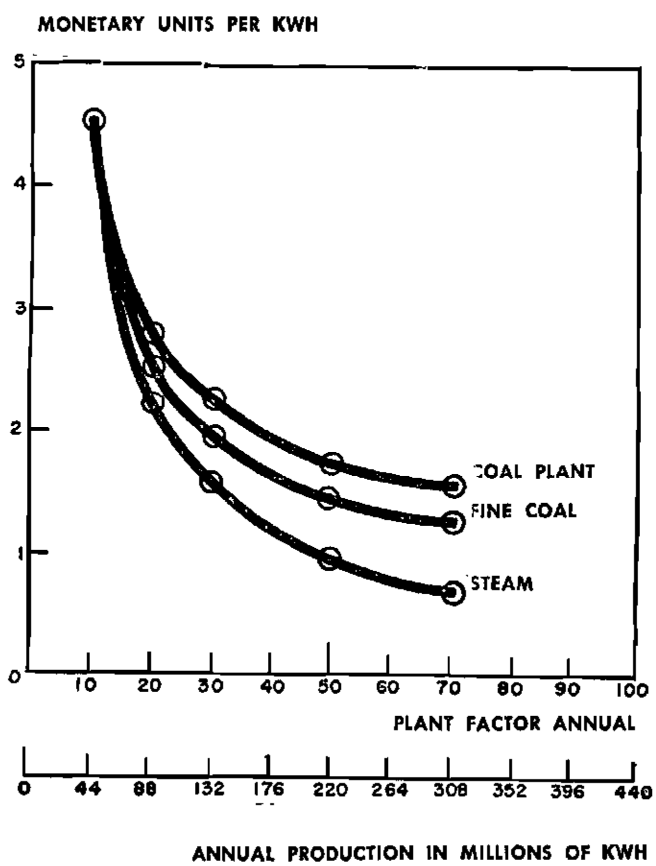
Figures 4 and 5 show clearly the results obtained from the data of this example. The first shows that the slope of the straight lines is much less for hydraulic plants, where fixed expenses form the greater part of the costs. The angular coefficient represents the variable cost which is very low for hydraulic plants.

Figure 5 illustrates the increasing difference and the notable decrease in unit costs as the plant factor rises, that is, the percentage of capacity used. With a plant factor of 10 per cent, the cost per kWh in monetary units is almost the same in all the three alternatives analysed: 4.54 for the coal plant, 4.53 for the hydraulic, and 4.22 using fines. With a plant factor of 70 per cent, there is a considerable decrease in costs for all three alternatives, but in different proportion. The coal plant falls to 1.58, coal fines to 1.0, and the hydraulic to 0.69.

Figure 5

CASE 38. COSTS PER KWH

NATURAL SCALE




### 4. *Some additional evaluation factors*

If the above methods are to be used to compare alternatives, certain other guiding principles must be considered, especially the plant factors at which the hydraulic stations could work. Thermal plants can operate, theoretically, at up to 100 per cent of their annual capacity, whereas the hydraulic plants are limited by hydrographical conditions, and by the extent of control of the flow considered in the study.[11] From the plant factor point of view, the graphs only show possible values in the alternatives studied.

Another essential consideration is the extent of transmission losses, which will generally be greater for hydraulic plants. If the services and primary transmission losses were, for example, 8 per cent for hydraulic plants and 5 per cent for thermal, the cost per kWh would have to be multiplied respectively by 1.08 and 1.05. Also, the specific costs of operation, maintenance and depreciation must be added.[12]

In the case of the thermal plants, the problem of coal (or other fuel supply) and any possible effects on the balance of payments ought to be given special consideration. In relation to coal, for instance, alternatives such as the following may arise:

(*a*) The country may have coal reserves which are not being worked, or mine output may be insufficient to meet the new demand. If the power-station plans to obtain its supplies from these sources, then consideration has to be given to the investments needed for opening up the mines or for increasing their present rate of production.

(*b*) Additional investments may be required for transport if the power-station is not located close to the mine. On the other hand, if by locating it at the mine it would be farther away from consumption centres than the alternative hydraulic plant, the investment for transmission has to be calculated, as in the case of the hydraulic plant.

(*c*) From the balance-of-payments point of view, it may be, for instance, that the country is a producer of exportable coal for which it has an established market. In that case, the thermal power station's consumption represents a loss in foreign exchange owing to lower exports. Conversely, if the country has to import coal, through shortages or lack of natural resources, this would also have effects on the balance of payments.

## *Case 39*

## INCOME AND EXPENDITURE BUDGET FOR OPERATING A FARM AND DESCRIPTION OF OTHER DATA RELATING TO IRRIGATION AND ALLOTMENT PROJECTS FOR AGRICULTURAL LAND

### 1. *Basic regional data*

No matter what evaluation criterion is adopted to establish priorities among irrigation projects, its practical

[11] See technical appendix to case 4 (chapter III).

[12] It has been proved that transmission losses have a notable influence as from 300 kilometres distance, and that they are less when using two cables than with one. The voltage at which the power is transmitted is also important, and it has been shown that at 380 kilovolts it is between 25 and 40 per cent cheaper than at 220 kilovolts.

application requires research into the position of agriculture in the zone affected by the project, so that the new operating methods can be compared with the existing ones. If farming in the zone only becomes possible by virtue of the projected works, preliminary experiments must be made to decide on the new forms of cultivation and the possible yields. In the last resort very preliminary estimates can be made, based on information from similar zones. The necessary regional data includes the following:

(*a*) Climate: precipitation, evaporation, temperature, humidity, winds, etc.

(*b*) Soils: type of soil, physical-chemical properties and other data relating to their classification.[13]

(*c*) Population: number and classification by ages, profession, sex, standard of living and social characteristics.

(*d*) Present use of the soil: areas under cultivation, present crops and yields, reasons for low yields—if any—proportion set aside for pastures and forests, proportion of land lost, plan for using the soil, prospects for new crops in relation to possible demand.

(*e*) Market situation in relation to agricultural commodities produced and consumed in the zone: transport, marketing and processing, prices, products that the region imports or exports from or to other parts of the country or abroad, projections of local demand and other relevant information.[14]

(*f*) Livestock herds: number and quality of producing and draught animals, meat production, milk, eggs, hides, wool, etc.

(*g*) Land tenure situation: size of present farms, ownership of the land, rental and partnership customs, communal lands, prices of land. Opinion as to possible need for expropriation or redistribution.

(*h*) Manpower situation: number of rural workers, wages, types of labour contract, migratory labour, labour requirements per hectare for the main crops.

(*i*) Methods and technical levels of cultivation: crop rotation, sequence and approximate dates of operations, use of fertilizers and insecticides, water requirements, silage and other practices.

(*j*) Current inventory of agricultural equipment: buildings, machinery, storage space available on the farms.

This information may be obtained from three principal sources, that is: from statistical publications (general and agricultural census data, production consumption and price statistics and other publications or reports); from local research (agricultural sampling and surveys of various kinds, experiments in the area, soil and water tests, special studies on farm management and others) and from information obtained when studying similar projects.

As a rule surveys of this type require personal interviews with a representative number of farmers, based on a carefully prepared questionnaire. Both the organization and the actual field work of the survey and its interpretation require specialized personnel.

### 2. *Data relating to the standard farm*

In addition to information relating to the region as a whole, estimates must also be made concerning the operation of typical farms in the different areas which it is proposed to irrigate, classified according to soil studies. The purpose of these farm studies is two-fold:

(*a*) to determine the farmer's capacity to pay, and (*b*) to estimate over-all production income and expenditure throughout the area.

#### (a) *Capacity to pay*

The "capacity to pay" of water users is understood to mean the maximum amount of money that the farmer can set aside each year to pay for water, after deducting the following items from his income:

(i) Costs of producing and marketing his products, taxes and interest on possible long-term loans obtained for purchasing the land, payment for installations and miscellaneous equipment (see table 97, for example).

(ii) Expenses necessary to maintain the family at its present standard of living or at a standard compatible with the political-social objectives pursued.

The capacity to pay is found from an estimated income and expenditure budget based on the operation of representative farms in the area to be irrigated. If the irrigation project also includes, as is often the case, settlement projects for the irrigated land, the adequate size for each lot must be determined according to the type of soil.[15] This requires study of alternative operating plans and the calculation of the corresponding income and expenditure budgets, which will provide an objective basis for deciding on policies relating to the price of water, the capacity to pay and the presumed standard of living of the settler.

#### (b) *Estimates for the entire area*

With the income and expenditure budgets for farms representative of the different types of land and with the general information mentioned earlier, over-all estimates can be made for the area which will benefit from the irrigation works. If the budgets for the standard farms are weighted in accordance with the area of each, an integrated income and expenditure budget can be obtained; this will be a useful instrument for evaluating the irrigation project or the plan for colonization.

Development of production, however, may well differ, depending upon whether or not the land is sub-divided. If the farms are large and dry, and they are given the necessary water without being divided into lots, there will probably be greater delay in complete utilization of the land. On the other hand, investments in the farm—apart from those implicit in the irrigation project—will be less if the land is not split up. Estimates as to the type, intensity and degree of land utilization are therefore related to the policy to be followed concerning land tenure and will hence affect evaluation.

Apart from questions relating to the general policy of water prices, division of land and credit facilities in relation to future proprietors, other basic guiding principles for verifying the income and expenditure budget are the following: size of the farm, amount of investment needed, labour supply and access to markets. By a trial and error method, it is possible to ascertain the size of the farm compatible, first, with the farmer's capacity to pay, and, second, with investment availabilities and social objectives. The final conclusions reached will obviously be decisive for evaluating the irrigation project, and this strengthens the importance of the factors just cited. The main aims are:

[13] See section 6.

[14] See a more detailed description of the implications of a study of this kind in Part One, chapter II.

[15] For problems relating to soil classification, see section 6.

(i) To determine which crops or types of animals are most suited to the soil and the size of farm in question and, on this basis, to establish the most desirable working programme. This decision involves adopting a preliminary hypothesis concerning the size of the farm and assumes that there are no problems concerning funds available for investment purposes nor as regards the availability, type and output of labour. It also implies a market study to decide on the possibility of selling the expected products.

(ii) Once an outline has been adopted as to the method of using the soil and the other resources available, to establish in what way the products are to be used; in other words, what part of them will be sold, used for the family, used to feed cattle, for seed, etc. Details should also be given of the projected use of pastures and crop residues.

(iii) To prove whether the agricultural and livestock plans are mutually compatible and are also compatible with labour and capital supplies. As a result, any necessary adjustment must be made.

(iv) To prepare a cash income and expenditure budget, as well as a general budget, including interest, depreciation and similar charges, according to the outlines explained later.

(v) To prepare a financing table to indicate the capacity to pay.

(vi) To verify the compatibility (*a*) between the capacity to pay according to the financing table and the requirements for developing the farm; (*b*) between the farmer's consumption expenses, estimated in the budget, and the social objectives pursued; (*c*) between the production available for sale and the market's capacity to absorb it.

(vii) To formulate the initial hypotheses once more until compatibility is achieved.

### 3. *Data relating to available water*

The technical characteristics of the irrigation works and the natural features of the available water resources will also have a bearing on agricultural projects. In certain cases they may be of great importance.

These characteristics refer essentially to the total amount of water available and to its distribution according to the system of water-courses utilized. It is understood that the decision concerning new crops in the zone to be irrigated will depend not only on soil characteristics[16] and on accessible markets but also on the water supply at the times suitable for each crop[17] and on the hydrological cycles throughout a period of years.[18]

From the standpoint of the irrigation work itself, the problem will be of different importance depending upon whether the water is drawn off the river directly by means of a canal, whether a reservoir is used exclusively for irrigation purposes, and whether a multiple-purpose project or other technical alternatives will be adopted. If the water is controlled seasonally by means of reservoirs, then the total available amount can be distributed throughout the year according to crop needs, and the problem of water systems will have no decisive effect on agricultural production. But if the reservoir is for several purposes—for instance, electricity production and navigation[19] then freedom to use the water for agricultural purposes will be restricted and this use will have to be reconciled with the other uses envisaged by the project. In that case, a comparison will have to be made between the seasonal supplies of water, according to the project, and the rates of irrigation required by the various crops throughout the year.

It should be stressed that not only are there variations in the use of water throughout the year, but also from one to another. That is why, in agricultural projects, hydrological security has to be considered, expressed as a percentage of the time when a given amount of water can be assured during the year. A safety margin of 80 per cent is usually acceptable in agricultural projects, which is the same as accepting that once in every 5 years there will not be the optimum amount of water for the plan adopted. Hence hydrological cycles will clearly affect decisions as to the type of cultivation to be adopted as well as the size of the reservoir required to permit seasonal and annual control.

The sub-division of the land can also affect the size of the farms, through the possible or desirable ratio between the land and the available amount of water. If there is relatively more land than water—discounting any possible demographic pressure—it will be as well to include in the farm territory portions of land for possible irrigation, so that the farmer can use them when water is available.

### 4. *Calculation of the capacity to pay and presentation of the income and expenditure budget*

The method of calculation is illustrated with an example taken from a series of lectures given at a training centre on the evaluation of agricultural plans and projects.[20] The figures are retained, although they refer to a case in the United States, so that monetary values are expressed in dollars and areas in acres. For purposes of method, the units do not matter. The type of production and destination of the goods produced will vary according to countries and areas, but the figures can always be organized and presented in the manner explained, indicating in notes or annexes the justification for each item.

The example assumes that a certain area of land is to be irrigated and divided up into family farms for settlement. Farmers will be given long-term credit facilities, both to pay for the land and to amortize other investments required for working the farm. Investment per 90-acre farm[21] are given in table 94.

In accordance with the pattern of investments, the land represents approximately 40 per cent of the total investment. The rest consists of buildings, installations, machinery and livestock. Income that the farmer obtains from operating the farm ought, then, to be sufficient not only to pay for the land but also for the other items to be financed with credits.

Table 95 shows the summary of the income and expendi-

[16] See also section 6.

[17] The rates of irrigation are usually expressed in terms of global coefficients such as annual cubic metres of water per hectare or litres per second and per hectare each year. But what is decisive is the way in which this amount or "water usage" is distributed throughout the year.

[18] See an explanation of the hydrological cycle and of river control in the technical appendix following Case 15.

[19] See remarks on allocation of investments in Part One, chapter V.

[20] E. J. Talbot "The role of agricultural economics in project evaluation", *Digest of Lectures—Arab Training Centre on economics and financial appraisal of agricultural plans and projects*, published by the Food and Agriculture Organization of the United Nations.

[21] One acre equals 4 047 square metres.

**Table 94**

CASE 39. INVESTMENTS PER FARM

*(Dollars)*

| | |
|---|---|
| Land | 5 400 |
| Buildings and improvements | 1 455 |
| Housing | 1 580 |
| Drinking water | 105 |
| Machinery and equipment | 2 620 |
| Livestock | 1 645 |
| Inventory (implements and foodstuffs) | 600 |
| *Total* | 13 405 |

**Table 95**

CASE 39. ANNUAL INCOME AND EXPENDITURE BUDGET FOR THE FARMER

*(Dollars)*

| | |
|---|---|
| 1. Receipts for sales of produce[a] | 3 329 |
| 2. Goods and services produced on the farm and consumed by the farmer[b] | 631 |
| *Total* | 3 960 |
| 3. Operating costs[c] | 1 919 |
| *Net income* | 2 041 |
| 4. Consumption within the home of goods and services not produced on the farm[b] | 1 500 |
| 5. Total capacity to pay | 541 |
| 6. Net total capacity to pay per acre[e] | 6.48 |
| 7. Maintenance and operation of the irrigation works per acre[f] | 1.75 |
| 8. Capacity to pay available per acre, to service credits[g] | 4.73 |

[a] See table 96.
[b] Meat, milk, butter, vegetables and flowers produced on the farm and consumed in the farmer's home. Also housing (see table 96).
[c] See table 97.
[d] Other foods than those mentioned in [b], clothing, medical services, electricity, entertainment, etc.
[e] It is assumed that of the total 90 acres, 83.5 will be net for operation as detailed in table 96.
[f] A figure that should be obtained from the study of the irrigation project.
[g] Possible credits granted to the farmer for the purchase of land and other assets.

ture budget and the way in which the capacity to pay is determined. In this table two capacities to pay per acre are calculated; the total (item 6) and that "available for servicing debts" (item 8). The difference (item 7) refers to charges made to the farmer for the upkeep and use of the irrigation works; included in these charges is the cost of the water to the farmer and the amount of the item that could be adjusted according to social-economic considerations based on the total capacity to pay and the amount of the debt services. The latter item will be a function of the amount of capital needed, of the proportion to be obtained in the form of credits, and of the term of these credits. If less is charged for the water, and the State absorbs the rest of the maintenance and operating costs of the irrigation works, there will be a greater capacity to pay for servicing debts, and the farmer can assume greater obligations. Conversely, it may be a specific objective to charge the farmer the entire cost of the irrigation water. The example of the Piura-Quiroz project, in Peru[22] clearly reveals the influence that price policy may sometimes have on water sales. In that case, when the farmers had to pay more for their water, they economized in its use, so that the irrigated area could be extended beyond the original estimate, thus increasing the general advantages of the project. That is why the adjustment between items 6, 7 and 8 in table 95 affects not only the farm's budget but the evaluation of the irrigation project. On the other hand, items 2 and 4 will affect the total capacity to pay (item 5), their total being the consumption of the farmer and his family. If these expenses increase without other estimates varying, the capacity to pay declines. The amount of such expenditure represents the farmer's standard of living, which may be one of the objectives pursued. Thus once again, the social-economic effects of the calculations may be appreciated.

Table 96 gives details of the amount and destination of the farm's output, the soil having been classified as first-class. The table is divided into two parts, one for agricultural crops and the other for livestock production. Production is expressed in physical and monetary units, and the destination of the products in monetary units. Three different destinations have been distinguished: use on the farm, consumption in the home, and sales. It is assumed that all the barley, oats, wheat, alfalfa, pastures and hay will be consumed on the farm itself to obtain the livestock production. Beet and beans will be sold and will return a monetary income. Finally, the garden and orchard occupy half an acre (some 2 000 m$^2$) and this produce is consumed in the home. Livestock production in this case has a different structure: it is sold or consumed in the home, but none is used on the farm itself as an input for other production.

The total value of production is 4 965 dollars per year; of these, 1 305 are used for the production itself, 331 are used in the home and 3 329 are sold. It can be seen from table 95 that 631 dollars were noted as goods and services consumed in the home instead of the 331 dollars shown in table 96. The other 300 were added to take into account housing services, since the house was also included among investments (table 94).

Table 97 sums up current expenditure for operating the farm. It is divided into three groups; overheads, expenses pertaining to agricultural operation and those pertaining to livestock. Interest included among the overheads pertains to the long-term credit which is assumed to have been granted to the farmer.[23] The feed costs included under livestock correspond to the extra feed for cattle and sheep, that has to be purchased outside the farm. The other items require no special explanation.

### 5. *Period for establishing the farm*

The preceding budgets refer to the result of operating the farm once it has reached what might be termed normal production. Nevertheless, in the case of agricultural operation, this will not take place in the first year, and a certain period of time has to elapse until normal output is reached.

Projects ought therefore to analyse—year by year—the development of production during that period and also the financial position of the farmer or settler. This analysis might, for instance, make it necessary to allow a

[22] Case 40.

[23] Assuming that the debt will be amortized, this item will in time disappear from the expenses.

## Table 96

### CASE 39. AMOUNT AND DESTINATION OF THE FARM PRODUCE

*(Extension: 90 acres. Soil type: I)*

| *Crops* | *Unit* | *Production* | | | | | *Destination (dollars)* | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *No. of acres* | *Yield per acre* | *Amount* | *Price* | *Value (Dollars)* | *Used on farm* | *Consumed in home* | *Sales* |
| Barley | Bushel | 10 | 36 | 360 | 0.66 | 238 | 238 | — | — |
| Oats | Bushel | 7 | 34 | 238 | 0.56 | 133 | 133 | — | — |
| Wheat | Bushel | 7 | 24 | 168 | 0.85 | 143 | 143 | — | — |
| Alfalfa | Ton | 27 | 1.9 | 51 | 10.25 | 523 | 523 | — | — |
| Hay | Ton | 13 | 8 | 104 | 1.88 | 195 | 195 | — | — |
| Sugar beet | Ton | 9 | 11.6 | 104.4 | 9.80 | 1 023 | — | — | 1 023 |
| Beans | Bushel | 10 | 22 | 220.0 | 2.45 | 539 | — | — | 539 |
| Straw, chaff and beet greens | | | — | | | 73 | 73 | — | — |
| Garden and orchard | | 0.5 | — | | | 100 | | 100 | |
| *Agricultural sub-total* | | *83.5* | | | | *2 967* | *1 305* | *100* | *1 562* |
| *Stockbreeding and animal products*[b] | | | | | | | | | |
| Dairy cows[c] | lb. | 10 | 250 | 2 500 | 0.37 | 925 | — | 92 | 833 |
| Dairy cows sold | Number | 2 | — | — | 60.00 | 120 | — | — | 120 |
| Calves (meat) | Cwt[d] | 6 | 2 | 12 | 10.74 | 129 | — | 22 | 107 |
| Fowls (eggs) | Dozen | 100 | 10 | 1 000 | 0.30 | 300 | — | 60 | 240 |
| Fowls (meat) | lb. | — | — | 730 | 0.20 | 146 | — | 36 | 110 |
| Pigs (meat) | Cwt. | 18 | 2.15 | 38.75 | 9.76 | 378 | — | 21 | 357 |
| *Livestock sub-total* | | | | | | *1 998* | | *231* | *1 767* |
| *Total* | | | | | | 4 965 | *1 305* | *331* | *3 329* |

[a] A bushel of wheat is 22 216 kg., of barley 21.77 kg., of oats 15.42 kg. and of beans 27.2 kg.
[b] The column "No. of acres" now becomes "No. of animals", and "yield per acre" is now "production per animal". The example assumes that there are 4 cows, 2 calves, 3 pigs, 1 bull and 2 horses. It should be also understood that the annual growth of this stock equals the amounts of meat sold as indicated in the tables, so that it remains constant; in addition it might be pointed out that just as production and consumption of straw on the farm was included among crops, so production and consumption of manure might be included among animal products.
[c] Butter fat equivalent in milk fat.
[d] United States unit equivalent to 100 lb.

Table 97

CASE 39. ORDINARY OPERATING EXPENSES OF THE FARM

*(Dollars)*

| | |
|---|---|
| *Overheads* | *855* |
| Interest | 402 |
| Taxes | 145 |
| Insurance | 15 |
| Amortization of improvements | 125 |
| Car (proportion of expenses attributable to farm operations) | 140 |
| Electricity | 28 |
| *Agricultural operating costs* | *898* |
| Seed | 70 |
| Harvesting | 80 |
| Fertilizer and disinfection | 30 |
| Machinery repair and amortization | 315 |
| Fuel, lubricants, grease for tractor | 155 |
| Labour, wages[a] | 238 |
| Miscellaneous items and contingencies | 10 |
| *Livestock operating costs* | *166* |
| Food | 71 |
| Dairy and veterinary instruments | 45 |
| Sundries | 50 |
| *Total* | *1 919* |

[a] Includes only the labour from outside the farm. Total labour requirements for the year were estimated at 389 man-days (196 for crops and 193 for livestock). This labour force could come from the following sources: owner: 250 man-days; family, 79 man-days; outside labourers, 60 man-days.

period of grace in servicing the credits envisaged, or to allow additional financing credits during that period. On the other hand, it might be considered that the amortization reserves included under normal operating costs ought not to be paid out in the first years, but should remain available to provide short-term financial resources.

As for a general evaluation for the project's entire useful life, these annual differences have a corresponding effect on the present worth calculations explained in Part Two.

### 6. *Soil classification*

It has been thought useful to include here some explanations on soil classification, which consists in surveying the land systematically and grouping it by categories according to homogeneous physical and economic characteristics. From the standpoint of irrigation projects, the specific purpose of classification is to establish to what degree and extent the various lands being studied are economically suitable for systematic irrigation, and to ascertain subsequently the more suitable forms of cultivation for each type. This naturally means that due attention has to be paid to market problems. It may be that the soil's physical properties and the weather conditions will lead to excellent technical results (high yields) but that the selected usage may not be the best form of operation, because of market limitations.

For market purposes, the best lands will as a rule be those suitable for more intensive crops and with the highest yields per hectare; therefore water for them will have a higher value per hectare than for those other poorer lands which have to be worked less intensively. The size of the farms necessary to ensure a given standard of living for the farmer will thus vary in inverse ratio to the productivity of the land.

Table 98

CASE 39. NET INCOME OF A FARM FOR VARIOUS TYPES OF LAND

| *Type of land* | *Acres irrigated Per farm* | *Net farm income* | |
|---|---|---|---|
| | | *Per farm* | *Per acre* |
| 1 | 50 | 3 154 | 63 |
| 2 | 65 | 3 092 | 48 |
| 3 | 120 | 3 253 | 27 |

For example, in the case of a study carried out in the United States, results were obtained which show the importance of soil classification on the influence this may exercise on the price policy for the water sold to the farmer (see table 98). To charge higher water rates for those farms having better lands is equivalent to following a policy of *ad valorem* taxation on the land and helps to prevent high-grade land from being misused. The adoption of this policy will be an important factor in estimating income and will therefore affect the evaluation of the project.

Briefly, then, the classification of soils and the determination of their capacity is important in order to ascertain the best use of the water and of the land, the size of the farms, the form and amount of payment for the irrigation works and the best system of charging for the water. The classification must therefore be of the highest quality and its results must be taken into account when evaluating irrigation projects.

There are two basic stages in soil classification. The first includes a physical examination of the soils to determine their capacity solely on the basis of physical-chemical properties, climate, available water and other characteristics of the agrological environment. In the second stage, alternative uses for the soil are analysed in terms of adaptation to the economic environment surrounding the different types of cultivation which are possible according to natural conditions. Once the land has been classified in relation to its physical-chemical properties and the other existing natural conditions, it can be re-classified and subclassified in terms of economic factors. Although the expert on soils will be mainly responsible for the technical work, the technical decision should not be taken without the participation of other specialists. This division into stages is rather conventional and is adopted to facilitate the explanation, since both the technical and economic principles ought to be borne in mind at both stages.

The principal factors influencing productive capacity or use of the land are:

(*a*) Climatic factors;

(*b*) Chemical, physical and biological properties of the soil (texture, depth, alkalinity, salinity, fertility);

(*c*) The topographical characteristics (slopes; contours and location of the land, including size and shape);

(*d*) The amount and quality of the water available, and

(*e*) Drainage, that is, the capacity for eliminating excess water, either from the surface or from the soil itself.

Apart from the market factor already mentioned, the basic economic factors influencing soil classification are the production costs and those of habilitating the land. An area of land with similar physical-chemical properties may require a sub-classification in terms of the habilitation costs for different portions of it. Such costs include those the farmer has to incur to clear, weed and level the terrain, build drains, irrigation ditches and similar items.

The amount involved depends to a large extent on topographical characteristics, but there are cases where these natural soil or subsoil characteristics may have a significant effect on such costs. Hence the economic principles is closely bound up with that deriving from natural conditions.

On the other hand, experience has shown that production costs such as labour, land improvements, equipment and water are not related solely to the type of crop and the nature of the soils, but also to topography and drainage. Given a certain type of soil, the size, shape and position of the fields will influence the forms of irrigation, the facility of the work and other operating factors, and these in turn will affect labour, equipment and water costs. Drainage may be natural or artificial and includes: the prompt removal of surplus surface water, to prevent the yields from falling and the quality of the product from deteriorating; the maintenance of the underground water level below the root zone; soil leaching, to maintain the proper concentration of soluble salts, within the correct limits for plant growth. All this naturally results in variable production costs depending on the amount or nature of the work necessary.

### 7. *Practical limitations*

The outline of the economic aspects of soil classification may be considered as a reference standard that has to be adapted to the reality of each case. In the first place, there may be limitations due to shortages of personnel or resources for carrying out all the necessary economic research. At the same time, the need to act may be urgent. On the other hand, the limitations may be serious if the physical nature of the soils, the short-term climatic changes or market difficulties make it difficult to decide on portions of land which are physically and economically homogeneous. Another important factor that may introduce complications is the distribution of investments already incorporated in the farm at the moment of irrigating and sub-dividing it. If some parts of the farm to be sub-divided and irrigated have improvements and installations and others have none at all, the necessary investments will differ greatly from one part to another, so that a new sub-classification will have to be made.

Demographic pressure in the zone to be sub-divided has also to be considered. This factor tends to lead to the formation of smaller family farms.

For these and other reasons, it is often difficult to decide on the "standard farm" representative of a relatively large region, so that the classification and rational allotment of the land is all the more complicated. In any case, the fundamental idea is to determine the appropriate farm size for each type of soil and to outline a working plan which will take into account the physical properties and natural aptitudes of the land for production, the investments already made in the farm, new installations and improvements needed, the market for its products, possible demographic pressure in the area and the social-economic conditions already mentioned in relation to the standards of living aimed at for the farmer.

Accuracy in the soil-classification specifications can be checked—through the preparation of estimated income and expenditure budgets such as those already explained—for each of the classes of land resulting from the proposed classification. The aim is to ensure that the classification really shows the significant differences in the capacity to pay, according to the different types of farm.

The relative importance of the different factors influencing the specifications for classifying land will vary from one project to another, so that it is essential to study and define them in each case. The tendency to use the same set of specifications for different projects should be avoided, unless of course the physical, economic and social conditions are similar. The bases for preparing specifications and soil classification standards, and for drawing up irrigation maps will always be derived from the economic and physical factors mentioned before. No rigorous methods can be followed, however, and experience and good judgment are of first importance when undertaking the work. This is particularly true when there is no experience of similar land and no data available for comparison purposes.

### *Case 40*

### DATA FOR EVALUATING AN IRRIGATION PROJECT

The data summarized here were used to assess the economic advantages of the Piura-Quiroz project, in Peru. The proposed objective is to irrigate 50 000 hectares of land, of which 20 000 would be used to grow cotton and 30 000 for food crops.[24] The following economic aspects were analysed: (*a*) the gross value of production and turnover rate of the total investment; (*b*) costs and advantages for the farmer; (*c*) effects of the project on public finances; (*d*) effects on the balance of payments and (*e*) other effects.

#### (a) *Gross income and turnover rate*

At an average of 9 Spanish quintals per hectare and at a price of 0.40 dollars per pound of cotton, the new cotton area will yield some 365 dollars per hectare. Adding the value of seed, which is approximately 130 dollars per hectare, gross annual income will be some 495 dollars per hectare, representing nearly 10 million dollars for the additional 20 000 hectares of cotton. In the case of the 30 000 intended for food production, two annual crops can be obtained—under irrigation—with a gross annual output per hectare estimated at 180 dollars, representing 5.4 million dollars per year.

The irrigation of these 50 000 hectares would therefore increase production by some 15 million dollars a year. Since the cost of the project, plus the cost of preparing the land, would add up to 36.5 million dollars, the turnover rate would be 15/36.5, or 0.40, a ratio considered very favourable for this type of enterprise.

#### (b) *Costs and income for the farmer*

In estimating the project's advantages for the farmer himself, the two types of farming foreseen in the study were considered once again, that is, cotton and food.

The estimates are summarized in table 99, which is commented on below.

1. *Land.* The project contemplates the prior expropriation of the land to be irrigated, and its subsequent subdivision and sale. A special law was passed to enable the Government to purchase 92 500 hectares, comprising not only the irrigable area, but also the mountainous part.

[24] See case 20.

**Table 99**

CASE 40. INCOME AND EXPENDITURE FOR THE FARMER

*(Soles per hectare)*

| | Cotton | | Foodstuffs | |
|---|---|---|---|---|
| *Investment* | | | | |
| 1. Land | | 11 000 | | 6 000 |
| 2. Land preparation | | 2 000 | | 2 000 |
| | | 13 000 | | 8 000 |
| 3. Loans | | 10 400 | | 5 900 |
| 4. Equity capital | | 2 600 | | 2 100 |
| *Income* | | | | |
| 5. Gross value of cotton production | | 9 880 | | — |
| Less: | | | | |
| 6. Payment for ginning | 2 340 | | | |
| 7. Export tax | 910 | 3 250 | | |
| 8. Value of production on the farm | | 6 630 | | 3 600 |
| *Balance*: | | | | |
| 9. Production costs | | 3 500 | | 1 750 |
| 10. Gross profit | | 3 130 | | 1 850 |
| 11. Sundry taxes | 100 | | 50 | |
| 12. Interest | 395 | 495 | 240 | 290 |
| 13. Net profit | | 2 635 | | 1 560 |
| 14. Income tax | | 390 | | 235 |
| 15. Net profit after taxes | | 2 245 | | 1 325 |
| 16. Loan amortizations | | 620 | | 390 |
| 17. Available for the farmer | | 1 625 | | 935 |

This latter will be administered by the Department of Forests, while the Department of Irrigation will be in charge of selling the arable land at an average price estimated at 11 000 soles for the cotton hectares and 6 000 soles per hectare intended for food production. The Government bought the potentially arable land at 200 soles per hectare and the land for afforestation at 25 soles per hectare. The total price paid by the government was 9.6 million soles, to which should be added the investments in the irrigation works, as explained below.

When the project was submitted for the consideration of the International Bank, no decision had yet been taken as to the size of the farms into which the land was to be sub-divided, but it was expected to range from 15 to 100 hectares. No difficulties were foreseen in selling the land, since previous experience had revealed that there were more prospective proprietors than there was land available. Buyers' registers were to be opened as soon as the construction work began. Those interested, who had to be qualified farmers, were required to indicate the type and size of the farm they wanted and deposit 10 per cent of the estimated land value. If the number of applications was too great, preference would be given to farmers requesting 25 hectares or less and the rest would be divided into 50 and 100 hectare farms. Nothing had yet been decided as to the form of sub-division. Some 3 000 hectares were expected to be sold and distributed in the first year of construction. The rest would be distributed during the second year, to give the farmers time to prepare the soil.

2. *Land preparation.* This item refers to the costs borne by the farmer to prepare for the land he receives (clearance, levelling, etc.)

The average cost of soil preparation has been estimated at 2 000 soles per hectare, which amounts to 100 million soles (5.0 million dollars) for the entire area covered by the project. There will naturally be considerable variations from one zone to another. For example, no clearing will be needed in some parts, and in others the value of the timber obtained will pay for clearance. The levelling cost will be between 1 000 and 1 500 soles per hectare and that of drains and ditches from 200 to 400 soles per hectare. The more irregular contours of the higher land will make the preparatory work more expensive, raising the average beyond that given above.[25]

Housing costs will not be very high at the beginning, since there are in the region ample supplies of simple construction materials, which will not cost the farmer very much, and which he can use to build his own home.[26]

3. *Credits.* According to the foregoing, it is assumed that the land will be handed over for a cash payment of 10 per cent, the balance of 90 per cent being payable over 20 years.

4. *Equity capital.* This is the difference between the total investment (items 1 and 2) and credits (item 3).

5. *Value of cotton production.* It is estimated that one hectare will yield 910 pounds (9 Spanish quintals) of Pima-type cotton. It was assumed that cotton would be exported at the rate of 0.40 dollars per pound—excluding export tax—although when the estimate was made the value was 0.49 dollars per pound. The long-term downward trend in prices was accepted by correlation with the "middling" cotton market in the United States. In February

[26] More detailed remarks on the influence of these factors on land classification may be found in case 39.

[26] For the entire zone the cost of permanent housing would amount to 2 million dollars.

1955 the average price of the "middling" type in that country was 34 cents per pound and the export price of Peruvian Pima was 49.21. Over longer periods it was estimated that "middling" would drop to 28 cents per pound, and that Pima woul ddrop proportionately to 40 cents, export price. At an exchange rate of 20 soles per dollar, the price in local currency would be 8 soles per pound and the value of production 7 280 soles per hectare. The price variation margins admitted in the project are considerable. The cotton producers in the area could stand a drop to 30 cents per pound, this being equivalent to the income and expenditure equalization point. This price would mean that United States "middling" cotton would fetch 21 cents per pound.

To obtain the gross value of production, income from the sale of cotton seed, estimated at 2 600 soles per hectare, should be added to the fibre value. The gross value of cotton production per hectare would therefore consist of 7 280 soles for the fibre[27] plus 2 600 soles for the seed (9 880 soles altogether).

6. *Payment for ginning.* Some 90 per cent of the value of the seed, representing the cost of ginning, must be deducted from the gross value of production.

7. *Export tax.* The export tax is 50 per cent of the difference between the export price and the "production cost" determined periodically by presidential decree. The last decision available for the study was that of June 1954, when the cost of producing Pima cotton was set at 6.00 soles (30 cents) per pound. Half the difference between this cost and the estimated selling price, which was 8 soles per pound, is 1 sol per pound; at 910 pounds per hectare, this gives the 910 soles noted in table 99.

8. *Value at the farm.* This was calculated as the difference between the gross value of cotton production (item 5) and the payments for ginning and for the export tax (items 6 and 7).

9. *Production costs.* Details of production costs are given in table 100; the figures for cotton and for agricultural production are shown separately.

[27] In round figures, this is equivalent to the 365 dollars used to calculate the turnover rate explained earlier in sub-paragraph (*a*).

**Table 100**

CASE 40. ESTIMATE OF AGRICULTURAL PRODUCTION COSTS

*(Monetary units per hectare)*

| | Cotton cultivation[a] | General cultivation[b] | |
|---|---|---|---|
| | | *Arable land* | *Pastures* |
| Water | 200 | 240 | 320 |
| Soil preparation | 250 | 360 | — |
| Sowing and cultivating | 600 | 400 | 100 |
| Pulverization | 50 | 60 | — |
| Harvest | 540 | 250 | — |
| Fertilizers | 600 | 200 | — |
| Insecticides | 250 | 100 | — |
| Seed | 30 | 90 | — |
| Transport | 90 | 75 | 125 |
| Maintenance | 125 | 125 | 75 |
| Administration and salaries | 150 | 200 | 200 |
| Social laws, etc. | 380 | 300 | 50 |
| Contingencies | 135 | 100 | 130 |
| *Total* | *3 500* | *2 500* | *1 000* |

[a] The ginning item is not included.
[b] It is assumed that the operations are divided equally into arable land and pastures, at an average production cost of 1 750 monetary units per hectare. The arable land yields two harvests a year of maize, pulse, vegetables and root crops.

10. *Gross profit.* Difference between items 9 and 8.

11. *Sundry taxes.* Apart from income tax, which is item 14.

12. *Interest.* With reference to item 3, 6 per cent is paid on credits for the purchase of land and 9 per cent (on credits for) farm preparation.

13. *Net profit.* This is gross profit (item 10) less sundry taxes and interest (items 11 and 12).

14. *Income tax.* Estimated at 15 per cent of item 13.

15. *Net profit after taxes.* This will be the difference between items 14 and 13.

16. *Amortization of loans.* As explained already in connexion with item 3, this will be 5 per cent of the credit for the land and 25 per cent of the development credit.

17. *Available for the farmer.* This is the net cash balance that would be available to the farmer annually, per hectare. The amount is net after paying interests and amortizing loans. Actually, the farmer would be saving the credit amortization, which is included in the budget. On the other hand, the figures in table 99 refer only to the first year of normal operation. As he pays his debts for land and preparation, the annual availabilities will increase because interest will decline. Items 12 and 16 will finally disappear altogether; so that the farmer's financial position will improve.

Briefly, then, table 99 reveals that the farmer can easily service the credits while establishing his economic position. This is understandable considering that the current value of rent in the region is 1 200 soles a year per hectare, a figure approaching the value indicated in the table for servicing credits in the first year (495 soles in respect of taxes and interest and 620 soles in respect of amortization for cotton, which is the highest).

### (c) *Effects of the project on public finances*

Among the data considered when judging the Piura-Quiroz project, was an analysis of the repercussions that this enterprise would have on public finances. Some assumptions had to be made, including a given form of financing, as explained below.

If the work began in the middle of 1955, it would be completed by mid-1958, according to investment schedule shown in table 101.

The sources for financing the part in national currency —about 210 million soles, equivalent to 10.36 million dollars—would be: (1) some 40 million soles obtained from the initial quota for sale of the land; (2) some 52 million soles of fiscal resources outside the budget; (3)

**Table 101**

CASE 40. INVESTMENT SCHEDULE 1955-58

*(Millions of dollars)*

| | Foreign currency | Local currency | Total |
|---|---|---|---|
| 1955 | 6.93 | 2.00 | 8.93 |
| 1956 | 4.82 | 3.95 | 8.77 |
| 1957 | 3.80 | 3.65 | 7.45 |
| 1958 | 2.45 | 0.76 | 3.21 |
| *Total* | *18.00* | *10.36* | *28.36* |

Table 102

CASE 40. SOURCE OF INCOME IN LOCAL CURRENCY DURING THE INVESTMENT PERIOD, 1955-58

*(Dollar equivalent of local currency)*

| | *Sales of land* | *Assumed loan in local currency* | *Total (annual expenses in local currency)* |
|---|---|---|---|
| 1955 | — | 2.00 | 2.00 |
| 1956 | 1.0 | 2.95 | 3.95 |
| 1957 | 1.0 | 2.65 | 3.65 |
| 1958 | — | 0.76 | 0.76 |
| *Total* | 2.0 | 8.36 | 10.36 |

10 million soles of the fiscal disbursement already made to expropriate the land, and (4) some 100 million soles of fiscal contributions in the period 1956-1958, charged to the budget for irrigation works, which normally amounts to 100 millions a year.

The portion of the investment in foreign currency (18 million dollars) would be financed with a 25-year loan at 4.75 per cent interest, with a 4-year period of grace.

The analysis of repercussions on the fiscal system also assumed the following: (i) that the 3.5 million dollars already spent during the first stage of developing the project would not be taken into account at the second stage,[28] (ii) that investments in local currency—after discounting payments to farmers during the initial stages—would be considered as a government loan, to be paid in 24 years at 4.5 per cent interest and with a 4-year period of grace; (iii) that during the period of repaying this assumed credit, the Government will not only obtain income from the sale of the land and water, but also additional revenue as a result of the production originated by the project.

Tables 102 and 103 summarize the result of these estimates, in dollars.

During the investment period, considering local currency only, the outline of income would be as shown in table 102. The assumed government loan granted to the project in local currency will therefore be the equivalent of 8.36 million dollars (170 million soles).

An income and expenditure table was presented for the operating period. Income would come from the sale of the land, the sale of water and the increased taxes. The first two concepts are calculated only on the basis of the price assigned to the land and water in the project. As for taxes, there would of course be a direct increase derived from the increased cotton exports, since there is a specific tax on these exports. An estimate was also made of the increase in revenue from other taxes, in terms of the relationship between production and the amount of these other taxes collected in the zone. The sum of the three items gives the total increased fiscal revenue derived from the project.

Expenditure consists of the maintenance and operation of the irrigation works, as well as the servicing of the external debt for 18 million dollars and of the assumed local credit equivalent to 8.36 million dollars. The sum of these three items gives the total expenditure of the project.

For the entire period considered for the servicing of credits, the total figures are those in table 103.

The original study showed the annual development of income and expenditure, and revealed that, as from 1960, there would be a surplus. Once the credits have been serviced, income from water sales will suffice to pay operating and maintenance expenses; in other words, after that date the project will cease to be a fiscal charge.

(d) *Effects on the balance of payments*

During the operation of the project, the balance of payments will be favourably affected by the increased cotton exports and the savings in food imports. On the other hand, the increased imports of machinery, transport and processing equipment and the greater consumer expenditure on imported goods arising out of the higher incomes conferred by the project, must all be taken into account. Finally, the servicing of the assumed foreign credits was considered.[29] Details of the calculation and its presentation are given in table 104.

Approximately one third of the exports will be paid for in dollars and not in other foreign currencies, so that the foreign exchange quota for servicing the loan will easily be covered.

(e) *Other effects of the project*

Finally, the other repercussions of the project were analysed, particularly in relation to labour. A brief version of the conclusions is sufficient to show the type of research carried out in this connexion.

The irrigable lands are close to expanding industrial districts. Their situation favours shipment through a nearby port, since there is an ample expanding market for the foodstuffs to be produced. On the other hand, the project will make a dual contribution towards stabilizing agricultural production in the area by supplying irrigation water and facilitating crop diversification.

The project will help to increase the demand for labour in the cotton lands during the planting and harvesting periods. In the lands under diversified production, the demand for labour will be stable, and it is anticipated that the families living in the zone will supply the requirements. At present, there is under-employment in the Piura area and in the high Andean lands in the vicinity. This labour reserve will be sufficient to meet maximum demands,

[28] See case 20.

[29] The problem of the incidence of projects on the balance of payments is explained in greater detail in Part Two, chapter III.

Table 103

CASE 40. TOTAL INCOME AND EXPENDITURE DURING THE PERIOD OF SERVICING OF CREDITS

*(Millions of dollars)*

| | |
|---|---|
| *Expenditure* | |
| Annual payments of the loan in dollars | 30.2 |
| Annual payments of the assumed credit in local currency | 12.2 |
| Administration, operation and maintenance | 8.4 |
| *Total expenditure* | 50.8 |
| *Income* | |
| Sales of land | 31.0 |
| Sales of water during the period | 10.5 |
| Increased taxes during the period | 36.7 |
| *Total income* | 78.2 |

**Table 104**

CASE 40. EFFECTS OF THE PROJECT ON THE BALANCE OF PAYMENTS OF PERU, 1958-80

*(Millions of dollars)*

| | *Expenditure* | | | *Revenue* | | | |
|---|---|---|---|---|---|---|---|
| | *Credit servicing* | *Increased imports* | *Total* | *Exports*[a] | *Imports saved*[b] | *Exports plus savings* | *Net balance* |
| 1958 . . . | 0.43 | — | 0.43 | — | — | — | —0.43 |
| 1959 . . . | 1.10 | 1.00 | 2.10 | 2.0 | 0.5 | 2.5 | 0.40 |
| 1960 . . . | 1.35 | 1.70 | 3.05 | 3.0 | 0.9 | 3.9 | 0.85 |
| 1961 . . . | 1.35 | 2.50 | 3.85 | 5.0 | 1.3 | 6.3 | 2.45 |
| 1962-80[c] . | 1.35 | 3.40 | 4.75 | 7.2 | 1.9 | 9.1 | 4.35 |
| *Total* . . | *29.88* | *69.80* | *99.68* | *146.8* | *38.8* | *185.6* | *85.92* |

[a] Cotton.
[b] Value of food production, which it is assumed will replace an equal amount of imports.
[c] Figures corresponding to each year of the period.

estimated on the basis of 1.5 workers per hectare. The project-makers estimate that if more labour is needed it will be supplied by the inhabitants of the smaller farms.

### *Case 41*

### INFLUENCE OF PLANT SIZE AND PERCENTAGE OF CAPACITY UTILIZED ON PRODUCTION COSTS IN A CEMENT-BLOCK FACTORY

The following case has been taken from one of the pamphlets which the United States Government publishes in order to provide basic information on different types of enterprises and thereby encourage initiative among businessmen and community groups.[30] The only data extracted from the pamphlet are those related to the influence on production costs of plant size and the percentage of capacity utilized. The statistics cited in the study are purely explanatory since they have lost their practical significance, but the presentation of the case and its analysis on the basis of these figures may form a useful and illustrative example.

Table 105 shows production costs in different sizes of plant, on the assumption that each plant would operate at 100 per cent capacity. In table 106, the daily costs are given for the same plant sizes and for the various percentages of capacity utilized in each (33.3, 50 and 75 per cent respectively).

Under the final headings in both tables, production costs have been calculated per utilizable unit, since any blocks that do not meet technical standards have to be discounted from total production.

Unit costs have been carried over to figure 6, where four cost curves have been traced for the four different plant sizes considered in the example. The economies of scale which result from both variations in plant size and differences in the percentage capacity utilized in each plant may thus be easily assessed.

Once the volume of demand and probable sales prices have been estimated, the figure is a helpful indication of the most suitable plant size for each case. It also includes some secondary curves which serve the same purpose.[31]

Thus, for instance, if the proposed target is 4 000 blocks per day, the intersection of the perpendicular line to the axis of the abscissae before the figure 4 000, with the curves for the medium-size and large plants, enable dots *a* and *b* to be estimated; these dots indicate what the unit costs would be in both plants for a daily output of 4 000 blocks.

Dot *a*, situated on the cost curve for the medium-size plant, shows that for this size 4 000 blocks could be produced at a cost of 16 cents each, using approximately 90 per cent of normal capacity, which, according to table 24, amounts to 4 410 utilizable blocks.

Dot *b* on the cost curve for the large plant shows that its unit costs per block would be 17.5 cents at a daily output of 4 000 blocks, since only about 45 per cent of capacity would be used. It is therefore evident that the medium-sized plant is the most appropriate for a market of the volume indicated, and would also require less initial investment.

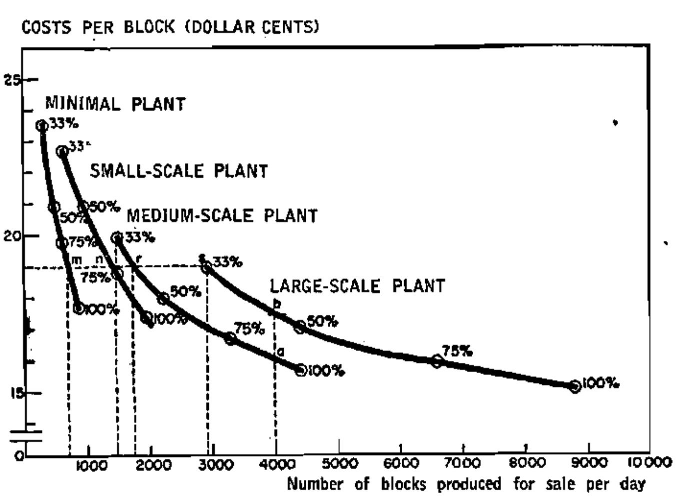
[30] United States Department of Trade and Agriculture, *Will making concrete blocks pay in your community?*, Industrial (Small Business) Series No. 23, U.S. Government Printing Office, Washington, 1945. Prepared by Mordecai Ezekiel, D'Alton B. Myers, John J. Quigley and Aaron J. Blumberg.

[31] None of the observations that are made after this point to the end of the example come from the original pamphlet, and the authors of the *Manual* accept full responsibility for them. The secondary curves in the figure are also not to be found in the original study.

**Figure 6**

CASE 41. UNIT PRODUCTION COSTS OF CEMENT BLOCKS WITH DIFFERENT PLANT SIZES AND DIFFERENT PERCENTAGES OF UTILIZATION OF INSTALLED CAPACITY

NATURAL SCALE



## Table 105

### CASE 41. ESTIMATED COSTS OF CEMENT-BLOCK PRODUCTION FOR DIFFERENT SIZES OF PLANT AND PERCENTAGES OF UTILIZED CAPACITY

*(Dollars)*

| *Items* | *Minimal plant Percentage utilized* | | | *Small-scale plant Percentage utilized* | | | *Medium-scale plant Percentage utilized* | | | *Large-scale plant Percentage utilized* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *33.3* | *50* | *75* | *33.3* | *50* | *75* | *33.3* | *50* | *75* | *33.3* | *50* | *75* |
| *Operation* | | | | | | | | | | | | |
| Cement | 15.67 | 23.50 | 35.25 | 35.00 | 52.50 | 78.75 | 78.84 | 118.13 | 177.19 | 157.48 | 236.25 | 254.38 |
| Admixtures | 9.17 | 13.75 | 20.63 | 20.67 | 31.00 | 46.50 | 46.80 | 70.20 | 105.30 | 93.59 | 140.40 | 210.00 |
| Sand | 1.50 | 2.25 | 3.38 | 3.33 | 5.00 | 7.50 | 7.50 | 11.25 | 16.88 | 15.00 | 22.50 | 33.75 |
| Labour pool | 4.00 | 10.20 | 18.00 | 4.00 | 36.00 | 48.00 | 36.00 | 48.00 | 72.00 | 60.00 | 84.00 | 132.00 |
| Foreman | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Electric energy | 0.20 | 0.30 | 0.50 | 0.40 | 0.60 | 0.90 | 1.00 | 1.50 | 2.50 | 2.00 | 3.00 | 4.50 |
| Commissions | — | — | — | — | — | — | 3.00 | 5.00 | 8.00 | 15.00 | 18.00 | 25.00 |
| Water | 0.20 | 0.30 | 0.50 | 0.40 | 0.60 | 0.90 | 1.00 | 1.50 | 2.50 | 3.00 | 3.00 | 4.50 |
| Coal | 2.00 | 3.00 | 4.00 | 4.00 | 6.00 | 8.00 | 10.00 | 15.00 | 18.00 | 20.00 | 25.00 | 35.00 |
| Petrol and oil | 3.00 | 5.00 | 7.00 | 6.00 | 9.00 | 14.00 | 13.00 | 18.00 | 27.00 | 25.00 | 34.50 | 54.00 |
| *Number of operation* | | | | | | | | | | | | |
| Interest | 3.50 | 3.50 | 3.50 | 7.00 | 7.00 | 7.00 | 13.00 | 13.00 | 13.00 | 20.00 | 20.00 | 20.00 |
| Depreciation | 9.00 | 9.00 | 9.00 | 18.00 | 18.00 | 18.00 | 33.00 | 33.00 | 33.00 | 65.00 | 65.00 | 65.00 |
| Light | 0.50 | 0.50 | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Heating | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Repairs | 2.00 | 2.50 | 3.50 | 3.00 | 5.00 | 6.00 | 5.00 | 9.00 | 12.00 | 12.00 | 20.00 | 24.00 |
| Office staff's salaries | 6.00 | 6.00 | 10.00 | 10.00 | 15.00 | 20.00 | 25.00 | 26.00 | 31.00 | 31.00 | 31.00 | 41.00 |
| Rent | — | — | — | — | — | — | — | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Depreciation (office) | 0.50 | 0.50 | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Stamps | 0.20 | 0.20 | 0.35 | 0.25 | 0.40 | 0.50 | 0.50 | 1.00 | 1.00 | 2.00 | 2.00 | 2.00 |
| Equipment | 0.20 | 0.20 | 0.30 | 0.25 | 0.30 | 0.50 | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Travel expenses in general | 0.50 | 0.50 | 1.00 | 1.00 | 2.00 | 2.00 | 2.00 | 3.00 | 4.00 | 3.00 | 5.00 | 8.00 |
| Publicity and miscellaneous | 2.00 | 2.00 | 4.00 | 4.00 | 5.00 | 7.00 | 7.00 | 10.00 | 15.00 | 20.00 | 25.00 | 33.00 |
| *Total cost per day* | *69.14* | *93.20* | *130.91* | *148.30* | *204.40* | *276.55* | *294.04* | *397.58* | *552.37* | *558.07* | *748.65* | *1 060.73* |
| Blocks per day | 300 | 450 | 675 | 667 | 1 000 | 1 500 | 1 500 | 2 250 | 3 375 | 3 000 | 4 500 | 6 750 |
| Utilizable blocks | 294 | 441 | 662 | 654 | 980 | 1 470 | 1 470 | 2 205 | 3 308 | 2 940 | 4 410 | 6 615 |
| Cost per utilizable block | 0.235 | 0.209 | 0.198 | 0.227 | 0.209 | 0.188 | 0.200 | 0.180 | 0.167 | 0.190 | 0.170 | 0.160 |

*Source: Will making concrete blocks pay in your community? op. cit.*

**Table 106**

CASE 41. ESTIMATED COSTS OF CEMENT-BLOCK PRODUCTION IN PLANTS OF DIFFERENT SIZES

| *Item* | *Unit costs* | | *Daily inputs for different sizes of plant* | | | | *Daily costs for different sizes of plant (Dollars)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Unit* | *Dollars* | *Minimum* | *Small-scale* | *Medium-scale* | *Large-scale* | *Minimum* | *Small-scale* | *Medium-scale* | *Large-scale* |
| *Operation* | | | | | | | | | | |
| Cement[a] | barrel | 3.50 | 13.5 barrels | 30.0 barrels | 67.5 barrels | 135.0 barrels | 47.00 | 105.00 | 236.25 | 472.60 |
| Admixtures[b] | ton | 2.50 | 11.0 tons | 24.0 tons | 54.0 tons | 108.0 tons | 27.50 | 62.00 | 140.40 | 280.80 |
| Sand | ton | 2.00 | 2.25 tons | 5.0 tons | 11.0 tons | 22.5 tons | 4.50 | 10.00 | 22.50 | 45.00 |
| Unskilled labour | hour | 0.75 | 3 men | 10 men | 15 men | 27 men | 18.00 | 60.00 | 90.00 | 162.00 |
| Foreman | day | 8.00 | 1 man | 1 man | 1 man | 1 man | 8.00 | 8.00 | 8.00 | 8.00 |
| Electric energy | kWh | 0.02 | 30 kWh | 60 kWh | 150 kWh | 300 kWh | 0.60 | 1.20 | 3.00 | 6.00 |
| Fuels | Thousands of gal | — | | | | | | | 10.00 | 30.00 |
| Water | Thousands of gal | 2.00 | 300 gal | 600 gal | 1 500 gal | 3 000 gal | 0.60 | 1.20 | 3.00 | 6.00 |
| Coal | ton | 7.50 | 0.66 tons | 1.33 tons | 3.0 tons | 6 tons | 5.00 | 10.00 | 22.50 | 45.00 |
| Petrol | gal | 0.20 | 40.0 gal | 80 gal | 160 gal | 320 gal | 8.00 | 16.00 | 32.00 | 64.00 |
| Oil | gal | 1.00 | 0.5 gal | 1 gal | 2.5 gal | 5 gal | 0.50 | 1.00 | 2.50 | 5.00 |
| *Number of operation*[c] | | | | | | | | | | |
| Interest[d] | % | 5.0 | 21 000 | 42 000 | 80 000 | 120 000 | 3.50 | 7.00 | 13.00 | 20.00 |
| Depreciation[e] | | | | | | | 9.00 | 18.00 | 33.00 | 65.00 |
| Light | kWh | 0.02 | 25 | 50 | 50 | 50 | 0.50 | 1.00 | 1.00 | 1.00 |
| Heating | | | | | | | 1.00 | 1.00 | 1.00 | 1.00 |
| Repairs | | | | | | | 4.00 | 8.00 | 15.00 | 30.00 |
| Office employees salaries | | | | | | | 12.00 | 20.00 | 31.00 | 41.00 |
| Taxes | | | | | | | | | | |
| Rent | | | | | | | | | 2.00 | 2.00 |
| Depreciation (office) | | | | | | | 0.50 | 1.00 | 1.00 | 1.00 |
| Stamps | | | | | | | 0.35 | 0.50 | 1.00 | 2.00 |
| Equipment | | | | | | | 0.30 | 0.50 | 1.00 | 1.00 |
| Travel expenses in general | | | | | | | 1.00 | 2.00 | 5.00 | 8.00 |
| Publicity and miscellaneous | | | | | | | 4.00 | 7.00 | 17.00 | 33.00 |
| *Total cost* | | | | | | | 155.85 | 340.40 | 691.15 | 1 329.30 |
| Total blocks per day | | | | | | | 900.00 | 2 000.00 | 4 500.00 | 9 000.00 |
| Utilizable blocks | | | | | | | 882.00 | 1 960.00 | 4 410.00 | 8 820.00 |
| Cost per utilizable block | | | | | | | 0.177 | 0.174 | 0.157 | 0.151 |

[a] Including freight.
[b] Light admixtures (slag and others) have been considered here. If heavy admixtures (crushed stone or gravel) were used, the weight would be 30 per cent more but a third less cement would be required.
[c] The original terminology has been kept.
[d] The figures in the inputs column for this item represent the amount of long-term credits.
[e] An estimate of 2.5 per cent has been made for buildings and of 15 per cent for machinery.

Let it be assumed that the break-even points are to be determined for a market price of 19 cents per block. A horizontal line drawn from before the corresponding point in the axis of the ordinates cuts the four cost curves at dots *m, n, r* and *s*. This means that if a minimal plant is to operate without losses, it would need a market of at least 700 blocks per day. Minimum production for the small, medium-sized and large plants would be 1 450, 1 750 and 2 950 blocks per day respectively. A comparison of these figures with estimates of demand will provide the basis on which to choose plant size.

**Figure 7**

CASE 41. VARIATIONS IN ANNUAL PRODUCTION COSTS FOR DIFFERENT PLANT SIZES AND DIFFERENT PERCENTAGES OF UTILIZATION OF INSTALLED CAPACITY

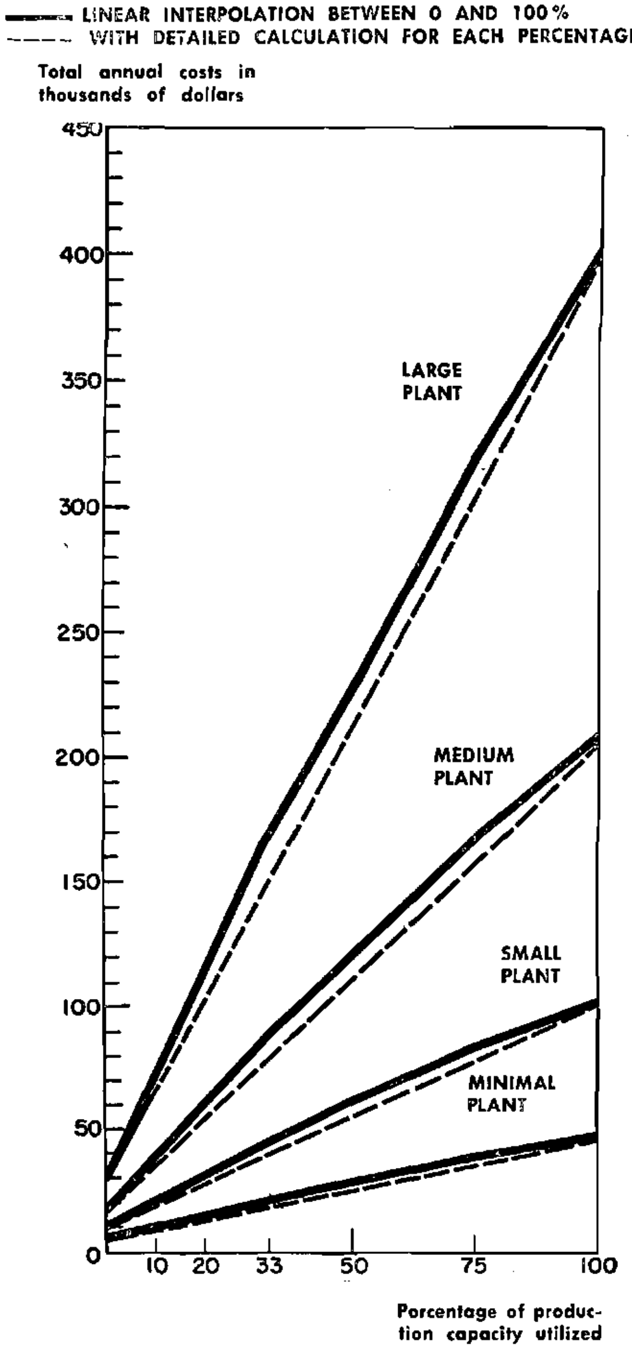



Figure 6 shows that one feature is characteristic of all four sizes of plant: in regard to their common margins of production, the margin chosen should always be that for which the largest percentage of capacity is utilized. For instance, for an output ranging from 1 450 to 1 950 blocks per day, which is a common margin for the small and medium-sized plants, the production costs of the small plant would inevitably be less, since it would operate at between 75 and 100 per cent of capacity. On the other hand, for the same margin, the medium-sized plant would have to operate from 33 to 45 per cent of capacity, and its costs would be too high for it to compete with the smaller. The case would be different if the cost curves intersected one another.

The statistics in tables 105 and 106 may also be used to illustrate the evolution of total annual costs for different percentages of normal production. In this case, costs may be more accurately assessed if strict proportions are observed between percentage and costs.

On the assumption that the factories in question work 300 days a year, total annual costs could be obtained by multiplying daily costs by 300. The same method could be applied to fixed costs as given in tables 24 and 25. The results have been included in table 26 and have been used as a basis for figure 7 in which the variation in annual costs for each size of plant has been traced by two curves. The straight lines are the result of joining the dots representing costs to percentages 0 and 100 for each size (e.g., 7 and 47 in the minimal plant). The other curves are obtained by joining up all the dots representing production costs to the different percentages enumerated in table 107.

**Table 107**

CASE 44. TOTAL ANNUAL AND FIXED COSTS OF CEMENT-BLOCK PRODUCTION FOR DIFFERENT SIZES OF PLANT AND PERCENTAGES OF CAPACITY UTILIZED[a]

*(Thousands of dollars in round figures)*

| *Percentage of capacity utilized* | *Size of plant* | | | |
|---|---|---|---|---|
| | *Minimal* | *Small-scale* | *Medium-scale* | *Large-scale* |
| 0 (fixed cost) . . | 7 | 11 | 17 | 30 |
| 33. . . . . . . . . | 21 | 45 | 88 | 167 |
| 50. . . . . . . . . | 28 | 61 | 119 | 224 |
| 75. . . . . . . . . | 39 | 83 | 166 | 318 |
| 100. . . . . . . . . | 47 | 102 | 207 | 399 |

[a] On the basis of data given in the pamphlet; their elaboration is the responsibility of the *Manual* only. It should be remembered that the figure are merely estimates in the pamphlet, and are not intended to refer to a real situation.

## Chapter VII

# FINANCING AND ORGANIZATION

### I. Introduction

There are two prerequisites for the realization of a project: knowledge of how to finance it and how to build up the enterprise that will be responsible for its operation. In brief, what is required is a plan for a specific type of undertaking, with sufficient actual or virtual funds at its disposal, that is capable of carrying the projected activities to their conclusion and directing production. Most of the practical problems that will arise during the execution of the project cannot be considered or solved in its study phase, and will be the responsibility of the enterprise itself, but the fundamental aspects of organization and financing, and those connected with the project's development from its formulation to the ultimate stages, should be analysed in advance. The elimination of future obstacles to a smooth passage through the transition period will depend on the extent to which the problems inherent in this stage are foreseen and dealt with and on an adequate definition of the basic structure of the new production unit. Before proceeding to the next stage, the project-makers will be superseded by executive and administrative staff, since the technicians who study the projects are not necessarily those who will be responsible for their installation and operation, although they may belong to the same organization. Obviously the staff in charge of the project must possess the requisite skill and knowledge, but even so, the obstacles mentioned earlier can be avoided only by advance planning of the type of organization projected and the method of transition from one stage to another.

Experience has shown that all efforts to forestall or solve the problems that may arise in the transition period still leave much to be done. The new organization will have to face legal problems, contract technical and administrative personnel, draft statutes and complete studies before reaching the final stage of the project; moreover, it will often be called upon to draw up equipment specifications, solicit and decide upon bids and, in general, undertake a series of tasks which would be considerably facilitated by being studied well in advance. This assertion is equally valid for projects in the public and in the private sectors, but carries more weight in the case of the former, in which projects have less flexibility and freedom of movement. When the project concerns an enterprise that has already been organized and is undertaking an expansion programme, the transition is relatively simple.[1] But when the problem concerns the establishment of a new organization it merits the closest attention.

[1] A clear example would be that of a power station in an electrification programme developed by a single national enterprise.

The financial aspects are closely related to those of organization. If, for instance, capital is to be contributed in the form of stock purchases, this involves a decision not only as to the methods of financing, but also as to the enterprise's social structure. Similarly, if a project in the public sector is financed by State funds contributed through public institutions A or B, or through various State or semi-State bodies, the financial aspects will naturally be linked to the structure and organizational framework of the enterprise.

In general, there is no justification for undertaking extremely detailed studies on organization and financing, in the absence of prior agreement on how to put the project into effect. Nevertheless, the allocation of a priority, and the decision *per se* to carry out the project, may sometimes involve specific legal, financial or administrative problems, as in the case of projects requiring expropriations, or the prior solution of conflicts over public control arising from defective regulations; those dependent upon the establishment of an autonomous public utilities enterprise;[2] those involving special problems concerned with search for or the use of certain patents, etc. When this type of question is brought into prominence by diverse circumstances, it may have an important effect on the formulation of certain aspects of the project, and even on the final decision.

On the other hand, financial limitations may be a vital factor in conditioning other aspects of the project, such as size or extent of mechanization, in which case the problem of financing must be considered simultaneously with the rest of the project and not subsequently. Finally, a project evaluation, from the standpoint of the private entrepreneur, must provide data relating to net return on capital invested, and hence a definition of the volume of credit and its rates of interest.

As the forms of organization and financing are interconnected to such a degree, it is difficult to settle their order of priority for consideration. It has been decided here—for explanatory purposes—to examine the financial aspects first, but in either case, it is advisable to distinguish between problems of installation and operation, and to emphasize the differences between public and private sector projects.

[2] There are cases, for example, in which the granting of credits depends upon the formation of autonomous enterprises to operate port services, or electric power stations, the administration of which is handed over to government offices depending from a Ministry.

### II. The study of financing

#### 1. *Objective*

Generally speaking, the financing process may be said to comprise two basic aspects: (*a*) the formation of savings, or the strictly economic aspect of the problem; and (*b*) the utilization and channelling of these savings toward the specific objectives sought, or the financial aspect.

Questions related to savings formation are not relevant to the study of an individual project, but should be considered rather in terms of an economic development policy, that is, on a more general basis. For individual projects, the study confines itself to an analysis of how to channel off part of the savings for use in the investment under consideration; it is at this juncture that the financial mechanisms themselves come into play.[3]

Fundamentally, the financial chapter of the project should indicate the sources of supply necessary for its execution and operation, and describe the mechanisms by which these resources would be directed towards fulfilling the project's specific aims. It should be explained whether the resources are, in actual fact, available, and how mechanisms suggested may be kept in touch with specific conditions. It is not sufficient to assert that an industry is financed by issuing stock without previously demonstrating that the possibility of placing such stock really exists. It is likewise inadequate to state that a certain part of the resources will be obtained through credits without discussing whether this may actually be done.

Naturally, the finance study must take into account the dates on which investment resources become available, in the light of the work programme and the investment schedule. The problem must be tackled globally, in local currency, and, for the partial investment components, in both local and foreign currency. Finally, a distinction must be drawn between the financing of fixed capital and operating capital, with their respective components in local and foreign currency.

For the purposes of clarity, the general aspects of the finance study will be dealt with first and then the special features of public sector financing will be examined.

### 2. *Financing of projects in general*

#### (a) *Sources of funds*

Funds for financing projects are provided by two general sources: undistributed profits and depreciation or other reserves, which are grouped under the heading of "internal sources" within the enterprises themselves, and the capital markets and banks, constituting the so-called "external sources". Both are connected since, if the undistributed profits and depreciation reserves are not reinvested in the enterprise concerned, they flow into the capital market and create a demand for other securities and values. The internal sources of certain enterprises are thus transformed into the external sources of others.

It is evident that financing based on internal sources will only be feasible when the project is developed by an enterprise already in existence. The profits retained represent what remains of the total net profits[4] after taxes, dividends or participation have been paid, and is an obvious source of savings. Of the remaining internal sources, the more important are the depreciation and obsolescence reserves, and the compensation for depletion of natural resources.[5]

The principal external sources for financing are various types of loans and capital investment in the form of common or preference stock. A distinction may also be made between access to external sources without financial intermediaries (direct sale of shares to the public) and with them (banks, insurance companies, brokers, etc.).

Loans are usually classified in three categories according to their duration—current, intermediate and long-term credits for periods of a year, 1-10 years and more-than 10 years respectively. Current credits (granted by banks or other enterprises) are used for financing part of the working capital, or for supplementing it in the case of, for example, seasonal fluctuations in the enterprise's operations. The other credits are used for financing fixed capital.

Common and preference stock are alike in that both are securities owned by the enterprise, but differ fundamentally as regards the priority enjoyed by preference stock for profits distribution and capital recovery in the event of the enterprise's failure or liquidation.

#### (b) *Limitations of the capital market*

In most under-developed countries, the capital markets are also poorly developed and may even be non-existent. Stocks and bonds are not as easily placed as in the industrial centres, and financing depends to a much greater extent on internal sources. Nevertheless, there are cases where access to capital markets in the big industrial centres is feasible, or where the local market is sufficiently well developed.[6]

In such cases it is desirable to decide what proportion of the investment will be financed by equity capital; this in turn depends fundamentally on the availability of such capital, the conditions governing credit grants, and the other projects envisaged by the enterprise. The availability of equity capital does not only depend on the volume of internal resources, but also on the possibility of placing stock or combining with other enterprises in the project. It will therefore be necessary to assess the stock market's capacity to absorb a future emission of shares. Credit terms available relate to duration, rates of interest, possible losses in the placing of securities and bonds and elasticity in their redemption, the imposing of special conditions such as the need to purchase equipment in certain markets,[7] intervention of the creditors in the administration of the enterprise and so forth.

### 3. *Equity capital and credit financing*

#### (a) *Basic aspects of the problem*

Equity capital is derived from the contribution made by interested investors, including the public sector. The legal constitution of this contribution is governed by specific circumstances and legislation in force. As the purchase of stock is the most common form of contributing capital to enterprises of some size, the utilization of reserves and

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[3] In any case, it should be remembered that a specific project can stimulate new savings that would not otherwise have been formed. It is possible to imagine an attractive and well-presented project that, together with other national factors, would induce a consumer group to save more. But it is not possible to anticipate or measure the influence exerted by such a project in this sense, and it can only be stated, in qualitative terms, that a good project may contribute to the formation of savings, as well as provide them with an outlet.

[4] Discounting depreciation and other reserves.

[5] Enterprises often set up reserves of other types which, in conjunction with those mentioned, provide resources for investment (for example, social insurance for the staff).

[6] Many publications deal with this aspect of the problem. See *International co-operation in a Latin American development policy* (E/CN.12/359), United Nations publication, Sales No.: 1954.II.G.2, and in particular Part One, chapter II, section III, pp. 31 *et seq.*, devoted to the question of the Latin American entrepreneur's access to international public resources.

[7] For example, the United States Export-Import Bank grants credits for purchases within that country only.

undistributed profits to finance new projects is also legalized by their conversion to free issue.

Long-term capital loans to the enterprise may be granted in various ways, the most usual being direct credits from an investment bank or development corporation, and the placing of securities and bonds on the market. These latter constitute credit instruments bearing an obligation to pay a specific sum of money on a fixed date, usually ten years after the issue, and an additional obligation to pay periodic interest, also on fixed dates usually falling due every six months.

There are different types of bonds or securities, the most important being mortgage bonds and preferentials or debentures. The first-mentioned, as indicated by their name, are guaranteed by specific assets in the enterprise, and are commonly used by railroad companies and public utility services, whose considerable volume of fixed assets permits them to pay a low rate of interest on mortgage bonds. However, mortgaged equipment may not be bought or sold as long as the debt is outstanding, and the enterprise's freedom of action as regards changing its equipment is thereby restricted. But in the case of projects whose guarantees are long-term assets, and thus less liable to technical improvement, these limitations are of no consequence, and enable mortgage bonds to be easily adapted to the exigencies of public utility services.

Manufacturing companies prefer to retain the freedom to buy and sell their capital goods at any moment, in order to be able to adjust themselves more easily to market conditions, especially in so far as technical innovations are concerned. For this reason, industrial bonds should be of the preferential or debenture type, carrying no especial guarantee and dependent for their placement upon public confidence in the stability of the enterprise.

In financing by bonds and securities, the holder of these acquires priority in the servicing of debts. At the expiration of the credit periods, or if the enterprise goes bankrupt, the capital lent also has priority as regards distribution of assets to be liquidated. An issue of bonds or securities may be totally or partially redeemed before reaching maturity, for the sake of convenience and upon the enterprise's decision. The statutes of the latter often provide for a sinking fund to cover the redemption of bonds, thus making periodic redemption obligatory. Optional redemption has its advantages in that it offers more flexibility to the capital structure of the enterprise, which in exceptionally profitable years, is able to redeem a greater number of bonds and place itself on a more stable financial footing, in order to face unfavourable years under better conditions. Advantage may also be taken of favourable circumstances to redeem bonds and securities placed under unsatisfactory conditions, and replace them by others less prejudicial to the enterprise. For example, if interest is declining, an old issue paying a high rate of interest may be withdrawn in favour of a new issue paying a much lower rate.

Although these factors may only be of limited interest to under-developed countries in which the capital and stock market is usually in an early stage of development, it is advisable to keep them in mind in case the local market has certain possibilities to offer, or access to the capital markets of large industrial centres is eventually secured. The criteria adopted for the project in this connexion will have a considerable bearing upon the enterprise's operations since, among the diverse methods of credit financing, some are much more adaptable than others to local conditions and the requirements of individual projects.

### (b) *Advantages and disadvantages of credit financing*

The advantages are as follows: (i) Control of the enterprise may be retained by one or more entrepreneurs or by the State, and, in the case of an issue of bonds or securities, for example, will be unaffected. It is obvious that this advantage is more apparent than real if the creditors or bankers holding bonds demand a share in the enterprise's administration, often accompanied by the power of veto. (ii) Investment institutions—banks and insurance companies—are not always permitted, for legal or statutory reasons, to affiliate themselves to other enterprises and may participate in their financing only through the purchase of bonds or offer of other types of credit. In order to have access to such financial resources, it may be necessary to request credit grants. (iii) Bonds are legally obliged to pay periodic interest and amortize the capital at the stipulated time limits. These guarantees may lead to the purchase of bonds or securities by investors at a lower rate of interest than that anticipated for shares, and it would thus be cheaper to pay interest on credits than dividends on new shares.[8] (iv) In many cases, credit financing results in substantial tax concessions. Interest paid, for instance, can be deducted from taxable income, but this does not apply to dividends. If a stock company holds preference stock paying fixed dividends, these form part of its profits and are consequently subject to income tax. Conversely, if bonds or securities, at the same rate of interest, are issued instead of preference stock, such interest is deducted from taxable income and the enterprise's profits after payment of taxes are greater by that amount.

The main disadvantages of credit financing are the following: (i) Many enterprises prefer to preserve intact their borrowing power to be called upon in emergencies. If their credit capacity has reached saturation point, such periods will be more difficult to negotiate. (ii) The interest is a fixed charge which has to be paid whether or not profits are declining. If the enterprise is operating at a deficit, the latter will be aggravated by the need to pay interest, but if stock had been issued in place of bonds, dividends would not have to be paid in such a case and the deficit would not be augmented. The payment of financial obligations, interest and amortization at fixed intervals may considerably weaken an enterprise's financial position.

One method of assessing the degree of indebtedness that may safely be incurred is to study the ratio between the project's estimated annual profits and the annual financial costs of the credits. The higher the ratio of profits to costs, the greater will be the possibility of payment. Moreover, if the estimated profitability of the project is higher than the rate of interest to be paid on debts contracted, it will usually be feasible to finance by means of credit, and the more so as the gap between the two increases.

### (c) *Solvency of the enterprise*

When a project is carried out by an enterprise already in existence, the possibilities of obtaining credit largely depend on the history and background of the enterprise and its current financial situation. For this reason, it is advisable

[8] In the case of an enterprise already in operation which has funds for investment, the solution will also depend on the amount of the funds and the alternative use to which they might be put.

to include the relevant information in the project description.

Financial results in the past may be assessed through the following type of information: general balance sheet; profit and loss account; depreciation and reserves policy; payment of dividends; re-investment of profits; sales policy; percentage of uncollectable debts, etc.

The current financial position can be shown as a series of coefficients expressing important rations, of which the following provide a sample: coefficient of available cash assets;[9] ratio between total assets and liabilities in the current account;[10] percentage composition of component items of total capital;[11] ratio between fixed equity capital and long-term debts; ratio between accounts receivable and payable; ratio of short-term debts to circulating equity capital, etc.

### 4. *Financing in local and foreign currency*

The financing study must also take into account the fact that the investment will be partly in local and partly in foreign currency. If there were no balance-of-payments problems it would be unnecessary to review the question from two angles since a guarantee of its financing in local currency would automatically be a guarantee for other currencies as well. Since, however, this is not the case in the majority of under-developed countries, it would be advisable to analyse this aspect of the problem, especially if there is a possibility of obtaining credit abroad which is usually granted for investment purposes in foreign currency. If credit is obtainable to cover that part of the investment that is in foreign currency, the effect upon the balance of payments will be dispersed over a period of time. This method of financing will thus fulfil a dual and highly important function, since it will lighten the burden of internal savings, and contribute to over-all stability by reducing the pressure of conflicting forces.

[9] Cash assets, plus easily liquidated securities, divided by current short-term debts.

[10] The term "assets in current account" comprises inventories plus liquid assets and collectable accounts, as well as securities and other easily liquidated items, or, in other words, total assets minus fixed capital. The liabilities total of the current account refers to short-term debts.

[11] Long-term debts, preference and common stock and reserves.

Some projects are partially financed by means of foreign capital from sources associated with the enterprise, instead of through credits. This also lowers the internal savings effort during the investment period.[12] In the case of enterprises with mixed domestic and foreign capital, the national source of supply must be revealed in the project as well as the conditions governing the contributions from abroad, since these data may be closely involved with legal questions of organization and administration.[13]

The favourable influence of certain projects on the balance-of-payments situation, whether by import substitution or increase of exports, may sometimes more than compensate for the outflow of foreign exchange to pay for a credit grant from abroad, in accordance with the need to finance part of the investment in foreign currency. Such an influence obviously plays a decisive part in the establishment of priorities.

### 5. *Tables of sources and uses of funds*

#### (a) *Different financing schemes*

The presentation of the various financing schemes is helped if they are set out in tables of sources and uses showing the origin of savings and their final destination, at three levels.

The first, or macro-economic, level would relate to the movement of funds and the financial inter-relationships between governmental, private, entrepreneurial and foreign sectors; this type of analysis forms part of the study on the financing of national development programmes and is outside the scope of the present text.

The data can also be grouped at a lower level, relating

[12] Foreign credit represents foreign savings invested in the country undertaking the project. Although this portion of the investment is included in what social accounting calls "gross internal investment", it does not form part of the country's capital formation process, since this depends only upon the extent to which the country saves and not the extent to which it invests. Foreign aid thus implies that savings from more developed communities go to foment the capital formation of less developed regions. See also the ECLA document: ***International co-operation in a Latin American development policy, op. cit.***, especially chapter IV, of the first part.

[13] For example, special regulations for foreign investors.

**Table VII**

UNITED STATES: COMPOSITE RECORD OF SOURCES AND USES OF FUNDS IN A GROUP OF 20 CHEMICAL-PRODUCT COMPANIES, 1946-51

| | *Millions of dollars* | | | *Percentage* | |
|---|---|---|---|---|---|
| I. Uses of funds | 2 927.3 | | | 100.0 | |
| 1. Construction expenditures | | 2 555.6 | | 87.3 | |
| 2. Increase or decrease in net working capital[a] | | 350.5 | | 12.0 | |
| 3. Other uses | | 21.2 | | 0.7 | |
| II. Sources of funds | 2 927.3 | | | 100.0 | |
| 1. Depreciation reserves | | 997.4 | | 34.1 | |
| 2. Retained earnings | | 997.8 | | 34.1 | |
| 3. New financing | | 887.0 | | 30.3 | |
| (*a*) debt | | | 342.4 | | 11.7 |
| (*b*) preferred stock | | | 412.3 | | 14.1 |
| (*c*) common stock | | | 132.3 | | 4.5 |
| 4. Other sources[b] | | 45.1 | | 1.5 | |

*Source*: John H. Perry, Ed., ***Chemical Business Handbook***, New York, McGraw-Hill Book Co., 1954. (Compilation by John H. Bohmfalk of Clark, Dodge & Co., New York.)

[a] Patents and sundries.

[b] Including changes in the pension and insurance reserves, etc.

*Note*: This table is reproduced by courtesy of the publishers.

**Table VIII**

UNITED STATES: SOURCES AND USES OF FUNDS FOR ALL CORPORATIONS EXCLUDING BANKS AND INSURANCE COMPANIES, 1947-51

| | *Thousands of millions of dollars* | | *Percentage* |
|---|---|---|---|
| I. Uses of funds | 121.4 | | 100.0 |
| 1. Plant and equipment | 88.6 | | 73.0 |
| 2. Net working capital | 32.8 | | 27.0 |
| (*a*) Increase of inventories | | 23.1 | |
| (*b*) Increase of receivables | | 26.1 | |
| (*c*) Increase of cash and United States Government bonds | | 14.1 | |
| (*d*) Increase of other current assets | | 0.6 | |
| (*e*) Decrease of accounts payable | | −12.3 | |
| (*f*) Increase of federal taxes payable | | − 8.5 | |
| (*g*) Increase of other current liabilities | | − 2.2 | |
| II. Sources of funds | 125.2 | | 100.0 |
| 1. Internal | 88.8 | | 71.0 |
| (*a*) Retained earnings and depletion reserves | | 54.4 | |
| (*b*) Depreciation reserves | | 34.4 | |
| 2. External | 36.4 | | 29.0 |
| (*a*) Increase in bank loans | | 7.8 | |
| (*b*) Increase in mortgages | | 3.9 | |
| (*c*) Net increase in new issues | | 24.7 | |
| III. Difference | 3.8 | | |

*Source: Op. cit.*, table VII.

to the movement of funds to finance individual economic sectors (e.g., textiles, iron and steel, chemicals, mining, agriculture). A knowledge of these data, as they appear in the sectorial tables of sources and uses, is useful for an initial grasp of the project. Such information is not always available in under-developed countries; for instance, the examples chosen to represent this kind of table concern a group of chemical industries in the United States (table VII) and the total number of corporations in the same country (table VIII). It may be seen from the latter that over two-thirds of investment in the sector in question came from domestic sources and that 87 per cent of new investment was intended for fixed capital.

A comparison of both tables reveals some of the differences which may exist between the sources and uses of funds in the two sectors. During the period under consideration, 73 per cent of new investment effected by all corporations was put into fixed renewable assets, as against 87 per cent for the group of chemical industries. Seventy-one per cent of the corporations' funds came from internal sources, while the corresponding figure for the chemical industries was only 68 per cent.[14]

The data on sources and uses can also be tabulated on the micro-economic level in order to show exactly how it is planned to finance the specific enterprise dealt with in the study. This table is naturally the most interesting as regards the project, and can be used to illustrate financing processes in both the installation and operation phases. It is essential to include the latter phase in order to prove that the enterprise will be able to service any long-term credits requested during its period of installation, and to indicate the over-all financial conditions in which it will operate.

(b) *Tables of sources and uses during installation*

The basic data employed in preparing this table are derived from the investment schedule and the projected financial resources to be used. The whole period envisaged in the investment schedule should be covered, and the data cited by year, or by other periods of time as in table IX.

(c) *Sources and uses during operation*

During this stage, the table takes on new characteristics since the sources will consist of income from the sale of goods or services to be produced by the project,[15] and the expenditure will involve operational costs (see table X). The basic data for preparing the table will be supplied by the income and expenditure budget, but there are several discrepancies between this and the table which will be pointed out later.

A table of sources and uses in the operational stage should trace the enterprise's anticipated evolution up to the moment when it reaches normal capacity and/or finishes servicing its long-term credits. This should be done primarily to show that, within its development possibilities, there is a reasonable certainty that the enterprise will be able to pay off its debts and/or have a sound financial structure; this can be objectively illustrated by a year-by-year calculation of some of the financial coefficients which entered into the previous discussion of the enterprise's solvency.[16]

The financial institutions studying possible credit grants

[14] The rapid expansion and relatively high rate of depreciation reserves observed in the chemical industries have greatly influenced their use of funds and the percentage of internal sources called upon during operation. Depreciation reserves represent half their domestic sources of funds, as opposed to less than a third in the case of other manufacturing enterprises.

[15] There may be other sources of income as, for example, Government subsidies.

[16] Section II, 3 (c).

**Table IX**

SOURCES AND USES OF FUNDS IN THE INSTALLATION OF AN ENTERPRISE[a]

*(Installation period estimated in years)*[b]

| | *Time intervals* | | |
|---|---|---|---|
| | *Año 1* | *Año 2* | *Año 3* |
| *Sources* | | | |
| A. *External* | | | |
| 1. Capital contributions . . . . . . . . . . . . | | | |
| (*a*) Preferred and/or common stock. . . . . . . | | | |
| (*b*) Other methods . . . . . . . . . . . . . . | | | |
| 2. Long—or medium—term, loans . . . . . . . . . | | | |
| (*a*) Bonds. . . . . . . . . . . . . . . . . . . | | | |
| (*b*) Investment banks and insurance companies . | | | |
| (*c*) Others. . . . . . . . . . . . . . . . . . . | | | |
| B. *Internal* | | | |
| 3. Undistributed projects. . . . . . . . . . . . . . | | | |
| 4. Reserves (depreciation and others) . . . . . . . | | | |
| 5. Previous year's balance . . . . . . . . . . . . . | | | |
| C. *Total sources* | | | |
| *Uses* | | | |
| 6. Land. . . . . . . . . . . . . . . . . . . . . . | | | |
| 7. Equipment and plant . . . . . . . . . . . . . . | | | |
| 8. Supplementary works . . . . . . . . . . . . . . | | | |
| 9. Study costs. . . . . . . . . . . . . . . . . . . | | | |
| 10. Organization, patents and sundries. . . . . . . . | | | |
| D. *Total uses* | | | |
| *Balance carried over to following year* | | | |
| (Difference between sources and uses, which is included in the following year's sources, according to item V.) | | | |

[a] The items have been grouped here in a conventional way. The break-down of each will be carried out according to the project-maker's criteria.
[b] It may of course be more or less. In the latter case, it may even happen that the last few years of the investment period overlap with the first years of the project's operation.

for the project will naturally pay special attention to the question of the enterprise's future solvency. Anticipated income should, in fact, be at least enough to pay production costs and service credits, within the conditions assumed for both.[17]

Mention has been made of cash availabilities and not of profits, because the problem of financing differs from that evaluation. The disparities between them are mainly due to the different standpoints from which the questions of reserves, interest and amortization of credits, income tax and divided payments are approached. It has already been established that costs should include an item for depreciation and interest, using the so-called "capital recovery factors". Assuming that both the reserves and interest charged have been included in the costs, and consequently in the sales price as well, they will remain on hand as liquid assets which may be counted upon for the servicing of possible credits. Moreover, income tax is not included among costs in the income and expenditure budget, since, for purposes of project comparison, it is usually more important to estimate profits before tax is paid. Conversely, when proving that credits can be serviced, the amounts to be paid out annually as profits tax must be estimated, since it is of interest to know the liquidity situation. Furthermore, in the table of sources and uses, anticipated amortization of credits and payment of dividends, which are not charged to production costs, are added to expenditure.

It may happen that a project has to operate for some time at less than normal capacity, during which period the enterprise is unable to service its debts or is run at a loss, but that the project nevertheless promises good results if the whole of its useful life is taken into consideration. In such a case, once the dangerous period has passed, the project will more than make up for its earlier losses. From the point of view of financing in general, the enterprise must therefore have enough capital to tide it over initial difficulties and must foresee that it may not be able to start servicing possible long-term loans before a given date.[18]

In other words, apart from what may be termed the normal financing of the project, additional financing should be envisaged for part of the enterprise's life to enable it to pass through the transition stage.

As regards the presentation of the financial scheme adopted, the table of sources and uses should be computed for each year at least during the enterprise's transition from a period of loss or cash deficits to the moment when it can begin to recover its losses and, finally, reach the stage of normal operation. The extra funds required annually can thus be clearly demonstrated. Any postponement in the servicing of credits entails an additional debt in the shape

[17] There are exceptions to the rule such as projects which do not fulfil this condition, but are carried out for social purposes (e.g., provision of roads, drinking water supplies, etc.). In such cases, the project must be able to count on special contributions, from the Government or other sources, to cover the deficit; these will also be included in the table of sources and uses.

[18] By means of the graphs already described in chapters IV, V and VI, the problem can be set out and analysed, and the break-even point determined at which the enterprise can begin to service credits.

TABLE OF SOURCES AND USES DURING THE PROJECT'S OPERATION

| | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | etc. |
| A. *Sources* | | | | | | | |
| 1. Sales | | | | | | | |
| 2. Subsidies or other sources | | | | | | | |
| 3. Previous year's balance | | | | | | | |
| B. *Uses* | | | | | | | |
| 4. Production costs[a] | | | | | | | |
| 5. Interest on short-term credits | | | | | | | |
| 6. Servicing of long-term credits (amortization and interest) | | | | | | | |
| 7. Taxes | | | | | | | |
| (a) Land and sales | | | | | | | |
| (b) Income and profits | | | | | | | |
| 8. Dividends to be paid | | | | | | | |
| 9. Difference (A-B)[b] | | | | | | | |
| 10. Depreciation and other reserves | | | | | | | |
| 11. Interest charged for pricing purposes[c] | | | | | | | |
| 12. Profits according to estimated budget for pricing[d] | | | | | | | |

[a] Excluding depreciation, reserves and interest.
[b] Transformed into "previous year's balance" in the sources account.
[c] Items 5 and 6 consider only interest to be paid on credits actually to be given; in item 11, interest on total capital in use charged according to the explanation in the text, is taken into account.
[d] Obtained by subtracting items 3, 4, 7(a), 10 and 11 from (A).

of compound interest for the non-serviced period, i.e., the interval between receipt of the credit and the inception of servicing.

Table X contains an outline of sources and uses of funds during operation. Items 1 - 9 show the movements of funds from which the annual liquid balance is obtained and carried over to form part of the following year's sources. Items 10 and 11 have been appended for illustrative purposes, since it is from them that item 12 may be obtained, i.e., profits calculated on the basis of the estimated income and expenditure budget.

This table does not require further explanation, though a brief comment should be made on item 8 "dividends to be paid". This concept will obviously depend on the policy of the enterprise; if nothing is paid for a year or so, it means that the enterprise is re-investing its profits with a view to financing expansions, amortizing long-term credits at the normal or a more rapid rate, or paying off short-term credits.

The balance in hand each year (item 9) may also be considered as the margin for complying with items 5 and 6 as regards possible credits. Likewise, the smaller the annual dividends paid, the larger the balance and therefore the margin of security. The amount of dividends to be paid therefore depends on the margin of security, which should be maintained at a certain level that may be expressed as the ratio of item 6 to item 9.

Financial organizations often lay down this type of condition for the granting of a loan, and the contract may include a clause in which the enterprise agrees not to distribute profits for a certain number of years or until it has repaid a specific percentage of the credit. Such prerequisites are easily represented in a table of sources and uses as explained above.

Data on the constituent elements of circulating capital and its financing may also be incorporated in the table relating to the operation of the project. The proportion of long-term credits and of equity capital that will be added to the sources to form circulating capital will be offset among the uses by current assets. An integrated table will thus be able to show when, how and in what way all the sources of funds projected for financing (both fixed and circulating capital) will be brought into play. The credits granted by suppliers and banks will be combined with the sources, and counter-balanced by the items in the "uses" section which refer to the amortization of short-term debts. More light is thus thrown on the enterprise's financial structure and the financial coefficients mentioned earlier can be more easily calculated.

As a working hypothesis, it may be assumed that, once the enterprise has begun to function normally, its current assets and liabilities would have the same structure, but that, until then, their structure would be modified yearly, especially if the enterprise does not operate at full capacity from the outset.

To sum up, the inclusion of data on circulating capital in annual tables of sources and uses has the following advantages: (*i*) the data indicate when credits or capital contributions would be required for financing the operation of the enterprise, and in what amount; (*ii*) they show the estimated composition of current assets and liabilities from year to year; (*iii*) they can be used for calculating some significant coefficients of financial stability.

### (d) *Over-all integrated table of sources and uses in the project*

Total integrated data on the financing of the project are presented in table XI, which constitutes a fresh method of tabulating the uses of funds. A comparison of tables X and XI shows that the servicing of long- and medium-term credits and the payment of dividends (items 14 and 15) have been omitted from uses during the installation period in table XI. Item 13—"Availabilities for payment of dividends, servicing of credits and formation of reserves"—which indicates the decision to be taken in this respect, has been included instead. When servicing of credits and payment of dividends have been deducted, the remainder—

**Table XI**

INTEGRATED TABLE OF SOURCES AND USES FOR PERIODS OF INSTALLATION AND OPERATION

| | *Installation* | | | | *Progressive operation* | | | | | | | *Normal operation* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* | *15* |
| A. *Sources* | | | | | | | | | | | | | | | |
| 1. Equity capital | a1 | a2 | a3 | a4 | a5 | a6 | a7 | a8 | a9 | a10 | a11 | — | | | |
| 2. Long- and medium-term loans | | b1 | b2 | b3 | b4 | b5 | — | — | — | b6 | b7 | — | | | |
| 3. Short-term loans: | | | | | | | | | | | | | | | |
| (*a*) Banks | | | | | c1 | c2 | c3 | c4 | c5 | c6 | c7 | c7 | | | |
| (*b*) Suppliers | | | | | | d1 | d2 | d3 | d4 | d5 | d6 | d6 | | | |
| 4. Sales | | | | | v1 | v2 | v3 | v4 | v5 | v6 | v7 | v7 | | | |
| 5. Previous year's balance | | S1 | S2 | S3 | S4 | — | S5 | S6 | S7 | S8 | S9 | — | | | |
| 6. Total sources | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 | F12 | | | |
| B. *Uses* | | | | | | | | | | | | | | | |
| 7. Fixed investment | i1 | i2 | i3 | i4 | | | | | | | | | | | |
| 8. Current assets: | | | | | | | | | | | | | | | |
| (*a*) Increase of inventories | | | | | f1 | f2 | f3 | f4 | f5 | f6 | f7 | — | | | |
| (*b*) Increase of accounts payable | | | | | g1 | g2 | g3 | g4 | g5 | g6 | g7 | — | | | |
| 9. Production costs (excluding depreciation and interest on long-term loans; including land tax and interest on short-term loans) | | | | | h1 | h2 | h3 | h4 | h5 | h6 | h7 | h7 | | | |
| 10. Servicing of short-term credits | | | | | t1 | t2 | t3 | t4 | t5 | t6 | t7 | t7 | | | |
| 11. Income tax | | | | | | | | | j1 | j2 | j3 | j3 | | | |
| 12. Total uses | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 | U11 | U12 | | | |
| 13. Availabilities for payment of dividends, servicing of credits and formation of reserves (A-B) | | | | | k1 | k2 | k3 | k4 | k5 | k6 | k7 | k7 | | | |
| 14. Payment of dividends | — | — | — | — | — | — | — | | | x1 | x2 | x2 | | | |
| 15. Servicing of long- and medium-term credits | — | — | — | — | m1 | m2 | m3 | m4 | m5 | m6 | m6 | m6 | | | |
| 16. Balance carried over to following year | S1 | S2 | S3 | S4 | — | S5 | S6 | S7 | S8 | S9 | — | — | | | |
| 17. Depreciation and other reserves | — | — | — | — | — | — | — | — | — | — | P1 | P1 | | | |

"Balance carried over to following year" (item 16)—is the same as in table X.

*Period of installation* (years 1-4). According to the table, fixed investment is effected for a period of four years, during which equity capital (item 1) is integrated in quotas a1, a2, 23 and 24. Equity capital may be derived from the issue of bonds or direct contributions in cash or other forms to be specified in each case. It is assumed that long- and medium-term loans (item 2) would begin in the second year after the enterprise had invested the sum of a1. Loans b1, b2 and b3 would help to finance investment i2, i3 and i4. It has also been assumed that annual contributions and loans would not necessarily be equal to investment in the same year, and that annual balances of S1, S2, S3 and S4 would be left. Balance S1 for the first year would therefore become a source of investment funds for the second year, and balance S4 for the fourth year would be carried over as a potential source for the fifth year, i.e., the first year of the enterprise's operation.

*Period of transition or development* (years 5-11). The enterprise would begin to operate in its fifth year and would therefore have to compile an inventory, pay production costs and prepare for possible losses incurred in starting operations, which would also be charged to production costs.

As regards the use of funds in the fifth year, the first item is f1 which represents the increase in current inventories (item 8(*a*)). As no inventory existed before, f1 equals the total inventory for the fifth year. The next item is g1, which corresponds to the increase in accounts payable (item 8(*b*)), i.e., in the credits which will probably be needed in view of the sales policy adopted. As no previous sales took place, this "increase" constitutes total accounts payable in the fifth year.

Production costs h1 (item 9) do not include depreciation or interest on long-term loans, but do cover land tax and interest on short-term credits. The latter forms item c4 in the list of funds corresponding to bank loans (item 3(*a*)) and are assumed to be granted for a term of less than a year. As the fifth year is also the enterprise's first year of operation, allowance must be made for a period of inauguration which is not expected to last for more than a year, and during which sales v1 will probably be made (these are included among sources of funds, item 4). In order to facilitate the lay-out of the example, it is assumed that losses and additional expenses entailed by the start of operations would be charged to production costs. In specific cases there would be no difficulty in separating them later and presenting them as a part of fixed investment. In fact, the whole of item 9 (production costs) may obviously be broken down as required.

Item 10 refers to the servicing of short-term credits, which, in the fifth year, would amount to t1, i.e., sufficient to pay bank credits c1 included among the sources of funds. Interest on short-term credits has been incorporated among production costs, so that c1 becomes equal to t1.

Mention has already been made of balance S4, sales v1 and short-term bank loans c1 among the sources of funds in the fifth year. In addition, new contributions of equity capital a5 would be available, that would evidently be intended to swell circulating capital, since fixed investment was completed in the fourth year. Lastly, it is hoped that a long- or medium-term loan b4 may be counted on, to be specified in each case. Total (item 6) sources of this kind, F5, will later be used to compile the inventory f1, maintain accounts payable at g1, pay production costs h1 and reimburse short-term credits by means of payment t1 (items 8(*a*), 8(*b*), 9 and 10).

The column for the fifth year may therefore be explained as follows: capital contributions and long-term credits (a5 and b4) are fundamental in forming the inventory and financing credits granted by clients listed among receivables; short-term credits c1 help to finance production movements by advancing funds for short periods; sales v1 assist in paying production costs and redeeming short-term credits within a year together with their corresponding interest; and the balance S4 plays a similar part among sources to that of capital contributions and long-term credits; in other words, c1 and t1 cancel each other out and are useful only in so far as they help the production process; sales v1 pay costs h1; while the balance S4 plus contributions a5 and loans b4 compose the inventories and accounts payable.

In the enterprise's fifth year and first year of operation, a balance k1 will result from the difference between total sources F5 and total uses V5 (item 13). This balance will be available for payment of dividends, servicing of long- or medium-term credits—which should begin in that year—and the formation of depreciation reserves (items 14, 15 and 17).

According to the table, the servicing of long-term credits (amortization and interest) is equivalent to m1, and no balance whatsoever is left with which to pay dividends or form depreciation reserves, i.e., k1 and m1 are equal. This equality is no mere coincidence, but arises from the adjustment to be made in items a5 and b4 so that commitments m1 for the first year of operation can be met. In other words, provision has been made for sufficient capital and loans to cover m1 in the fifth year.

The disposition of the figures in the sixth year follows the same general lines, with a few innovations added. For instance, the sources will also include short-term credits from suppliers (item 3 (*b*)) which will play exactly the same part as that of short-term bank credits (item 3 (*a*)); they will be given and paid within a year without leaving any balance, but since a delay in payment would be equivalent to anticipating income for helping the production process, the credits have been considered as a source of funds.

No balance will be carried over from the preceding year to form part of the sources in the sixth year, as explained earlier. Total sources are thus F6.

Among uses, t2 represents the increase in inventories as against the corresponding figure for the fifth year which was f1. The latter was financed in that year and remained in existence thanks to the sources a5 and b4; thereafter, with the aid of sources a6 and b5, it increased by f2, and the total inventory is therefore f1 plus f2. The same procedure takes place in regard to account payable g2.

Production costs h2 are assumed to be distinct from and also larger than h1, since the percentage of utilized capacity increases. (Inventories and accounts payable increase for the same reason.)

Item t2 should be enough in the sixth year to pay both suppliers and banks from current assets, i.e., t2 will be equal to the sum of c2 and d1.

The difference between sources and uses gives a balance k2, which is sufficient to service long- and medium-term credits (m2) and leave a balance of S5 to be incorporated in the following year's funds. No provision has been made to pay dividends in the sixth year.

There are no further explanations to make in relation to the seventh and eighth years when production is assumed to continue increasing. Increases f3 and f4 take place in inventories and g3 and g4 in accounts payable. New capital contributions a7 and a8 are also made, but additional long- or medium-term credits are not expected to be necessary. The policy of not distributing dividends is maintained, either because no real profits have been made or in order to reduce the quantity of new capital contributions or make further credits unnecessary. According to table XI, the most appropiate explanation appears to be that no real profits have been made, since income-tax payments (item 11) do not appear until the ninth year (j1).[19] Contributions of equity capital continue uninterruptedly and expand production until the sales volume becomes v6; in the tenth year, it is assumed that new credits b6 are obtained for the same purpose. The increments in production require increases in inventories and accounts payable (f6 and g6) and there is a corresponding rise in production costs which reach h6 in the tenth year. The first dividend is paid in that year, which, according to the table, amounts to x1, and a balance of S9 remains for the following year's funds after long-term credits have been serviced.

The enterprise reaches normal production in the eleventh year, with a sales volume of v7, for which a final capital contribution (a11) has to be made and a long-term credit b7 requested, apart from short-term credits c7 and credits from suppliers d6. The balance S9 carried over from the previous year completes the sources of financing.

The inventory increases by f7 and accounts payable by g7. During the normal operation of the enterprise, inventories required therefore amount to the sum of f1 and f9 and the volume of accounts payable to the sum of g1 and g7.

Normal production costs when the enterprise is working at full capacity are h7 and income tax j3. The balance k7 is used to pay dividends and service long-term debts by means of instalment m5. The remainder can go towards building up the enterprise's reserves. No provision has been made in the table for a balance to be carried over to the following year, so that the enterprise may, if it wishes, invest the reserves in other projects. The alternative would be to leave these reserves in the form of balance S10 and, in the twelfth year, reduce the amount of short-term loans or credits from suppliers. The decision again depends on the enterprise's economic policy which can be discussed in relation to the project.

The repercussions of either alternative are clear: on the one hand, the reserves would be "put to work" in the enterprise itself, thereby replacing credits from third parties with the consequent saving in interest payments and strengthening the enterprise's financial situation. On the other, they would be "put to work" outside, thus bringing in a certain amount of extra profit, altough interest would have to be paid on circulating capital.

The twelfth year is the first year in which the enterprise begins to operate normally, and new contributions of equity capital or more credits are not thought to be required. Short-term credits c7 and those from suppliers d6 are available, as in the eleventh year, and the same sales volume v7 is obtained, which represents that of full capacity. There is no balance from the preceding year with which to finance normal operations, since, as shown in the table, it was preferred to invest reserves outside in the eleventh year. Inventories, accounts payable and production costs show no increases over their levels in the previous year. It is estimated that prices would be the same and that the enterprise would work at full capacity in both years, so that the only variation in costs would arise from a change in the interest paid on short-term credits;[20] however, as c7 and d6 are the same, h7 and consequently k7 are also maintained from one year to another.

From a comparison of the columns for the eleventh and twelfth years, k7 is seen to appear in both years; the sum of a11, b7 and S9 which are included in the eleventh but not in the twelfth year is therefore equal to the sum of f7 and g7, which also appear in the eleventh year only.

The item k7 has the same distribution as in the eleventh year. It may be affected by changes in the intervals and types of amortization payment for long- and medium-term loans, which are also a potential source of variation from the twelfth year onwards. It is assumed in the table that servicing m6 will be the same in the tenth, eleventh and twelfth years in order to simplify the example.

Some lines have been omitted from the table which would have indicated to coefficients which could be used to trace the financial situation of the enterprise year by year on the basis of the data in the same table.[21] The calculation of such coefficients can be facilitated by making separate annual estimates of the enterprise's financial situation showing the variations in equity and long- and medium-term credits. All the relevant data can be obtained from the table, since it also indicates the yearly situation of capital contributions, credits and amortization.

The foregoing explanations show that an integrated table of sources and uses may be used to present, in statistical form, the following aspects of a project: (i) the work programme for installing the enterprise which may be summarized in uses of funds during the installation period; (ii) the amount and schedule of fixed investment; (iii) the method of integration and the composition of circulating capital; (iv) the income and expenditure budget; (v) the policy to be adopted on dividend payments and formation of reserves; and (vi) the evolution of the enterprise's financial situation.

### 6. *Financing of projects in the public sector*

Projects in the public sector are financed by credit surpluses from the current account of this sector, and by loans obtained from the local private sector or external sources. As the surplus is derived from taxes paid by the community, the formation of such savings may be said to have been obtained, on the whole, through the tax system. The allocation of funds for specific investments will, of course, be decreed by the Government, and financed by fiscal or semi-fiscal institutions. In this way, the problem of obtaining and allocating resources for projects in the public sector is intimately connected, on the one hand, to fiscal policy and, on the other, to the objectives of the programme.

[19] Other explanations might be valid (e.g., that a tax exemption was granted for the first four years, or that profits below a certain minimum were not taxed).

[20] If the balance S10 had been inserted for the eleventh year instead of the reserves P1, it would have been carried over to become a source of funds in the twelfth year, and would have reduced c7 and d6 and consequently the interest.

[21] For instance, item 13 divided by item 15; item 3 divided by item 4, etc.

The financial mechanism of State investment projects frequently depends on contributions from development corporations and similar institutions which, in their turn, receive direct support from the national budget or are financed by certain special tax legislation. When these government bodies have been operating for some time, they accumulate a certain amount of income of their own, which can be added to the State subsidies and used for purposes of financing. A large part of such income may derive from items such as the recovery of development credits, or profits from government-owned enterprises. Public utility rates often constitute a satisfactory means of providing investment funds, and the decision to use them for such a purpose is essentially a problem of State policy. For example, in order to expand electric energy production, one solution is to raise the rates and use the proceeds to form a special fund designed to finance such expansion; recourse to this method implies that it has been preferred to the alternative of utilizing the budgetary and tax mechanism or a series of loans for the same purpose.

The investment required for the project may be totally or partially supplied by internal or external, short- or long-term credits.[22] It is clear that the final decision as to whether a project should be financed by government contributions from a surplus in the current account, or by loans, increased rates or other methods, will depend upon institutional conditions and the fiscal policy to be adopted.[23]

Projects financed by income derived from the public sector are exposed to the serious risk of falling behind in their investment schedule, owing either to an error of calculation regarding the availability of future funds, or to defects in the public investment programmes.

If it is intended to finance numerous and varied public activities by the proceeds from different taxation sources selected at random, the fiscal system may well be asked to provide beyond its capacity, and any projects waiting for overdue fiscal or tax contributions are liable to go bankrupt. This risk substantiates the need for investment and work schedules that permit the installation of partial units of production, as long as this compromise does not in any way conflict with the nature of the project.

The dangers enumerated may be attenuated if the project forms part of a homogeneous development programme, but even in those cases where a projection of the public sector's current account is unobtainable, the general possibilities outlined earlier should be kept in mind.

[22] Direct credits from individual sources or from banks, issue of bonds or other securities and combined solutions.

[23] Financing by inflationary measures is rejected on principle.

## III. ORGANIZATION

The problem of the organization, establishment and future operation of the enterprise is of interest to the planner because, during the stage in which the project is formulated, certain important questions may arise affecting subsequent stages. The general or detailed problems of the establishment and operation of the enterprises, as already stated, constitute a separate phase and will be entrusted to specialized personnel.

Here, a brief survey will first be made of the general organizational problems which may arise during the study phase, followed by additional comments on the specific problems arising in the public sector.

### 1. *General problems of organization*

#### (a) *Establishment of the enterprise and legal dispositions*

The type of enterprise to be established (stock company or another kind), legal arrangements for the issue of bonds, etc., should be stipulated in the project and be accompanied by a draft outline of the statutes in the case of a stock company, or other similar data in accordance with the different forms of legal structure envisaged.

A private enterprise completely unrelated to the public sector is almost inconceivable in reality. Some contact is always maintained with governmental or provincial authorities in the form of municipal permits, establishment authorizations, import licences, etc. From these contacts the problem of "official relations" originates, the complexity and importance of which will differ from country to country, but which will nevertheless be omnipresent. It is not possible to foresee all the contingencies that may arise from this aspect of the problem, but there are some which are fundamental. Thus, for instance, if a certain location has been selected for an enterprise, for technical and economic reasons, this particular choice will have to be supported by the legal regulations in force. Similarly, if the authorization for the legal formation of a stock company has certain statutory time-limits, these must be co-ordinated with the requirements of the work schedule such as the regular receipt of investment credits granted. Although accorded in principle, these credits are not delivered until the enterprise is legally established and any negligence in this respect will entail delays solely because of faulty timing.

The case of those projects which depend for their satisfactory operation upon certain incentives from the public sector is extremely important.[24] Such a project may have been assigned a priority status by an official body without the necessary favourable market conditions being present. In these circumstances, its success will depend on the prompt application of those measures of promotion which were thought desirable when the project was first accorded priority, in view of the normal time-lag between their formal approval and promulgation. The project must be more than explicit in this sense and should also anticipate as far as possible the arrangements essential to the success of its work.

Similar problems are brought up by projects in the public sector. Although in theory the public sector is homogeneous, it is divided in practice into numerous administrative sections the perfect co-ordination of which is difficult to attain. It may well occur that a fiscal enterprise may be organized upon the lines of a private firm, although financed and run by the public sector, and then left to its own devices. If such an enterprise were planned with certain legal incentives and modifications in mind which

[24] Protective customs tariffs, tax exemptions, abolition of preferential exchange rates for competing imports, etc.

later failed to materialize at the right time, the result could be a series of losses eventually leading to the shutting down of the plant and its possible failure.

(b) *Engineering and administration*

It will be useful to include in the project a study of the general technical and administrative framework to be given to the enterprise. It must be emphasized that there is no question of attempting to solve all the administrative problems in advance, but merely of indicating the broad lines of the organization in order to forestall certain special problems.

It would be wise to try to avoid possible disputes for authority at the upper levels of the various organizational branches, as it is precisely these highly-placed staff who will later have to solve similar problems on the lower personnel levels. In any case, it will be very helpful to make a prior definition of the over-all organizational framework during the two phases of study and operation of the enterprise.

Certain problems of detail may also arise which it would be better to resolve at an early stage in order to avoid future setbacks. For example, if it is intended to take out a foreign patent and to employ the technical services of the proprietors, it would be useful to make administrative provision for the consultants who will be loaned for this purpose, and to deal with any legal aspects connected with the payment of their fees in foreign currency or other problems arising from the contracting of technicians outside the country.

(c) *Installation and operation*

The administrative structure required by these two stages of the project may differ completely from one to the other. For instance, the construction is often in the hands of contractors who are responsible for handing over the enterprise in running order. In such a case, the duties of the administration will be confined to those of supervision and preparation for taking charge of the operative stage once the construction work is terminated. If, however, the same enterprise were to construct and administer the project, the problem would be completely different. These aspects of the project should be studied beforehand. The possible alternatives should be considered and the proffered solution justified.

(d) *Requests for tenders*

The project may have been approved on the basis of the draft studies, and therefore, without details or final specifications. In this case, the stage of transition and organization may coincide with that of specification, requests for tenders and award of contracts. The initial construction stage will be facilitated if the project states the method and criteria on which requests for tenders will be based as, for example, whether there will be any stipulations as to credits, delivery dates, type of guarantee, etc.

### 2. *Administrative arrangements for projects in the public sector*

The financing of a project in the public sector is always connected with the administrative arrangements for organizing the enterprise to carry it out. For this reason, it is advisable to consider both aspects, and to specify the resulting administrative relations.

To take an example, if a development corporation is responsible for financing an enterprise with State funds, the necessary administrative arrangements should be made to ensure that these funds are received and to establish adequate control over their investment. From the project's point of view, it is of particular concern to possess reasonable guarantees both for the delivery of the fiscal quotas and for their satisfactory administration. This concern arises out of the undeniable desirability of ensuring the flow of resources in general as well as of meeting possible specific conditions for obtaining foreign credit. International credit institutions are especially interested in securing guarantees of the presence of funds in local currency and of the enterprise's efficient administration.

It will frequently happen that several governmental bodies participate in a project, whether because of its nature, for financial reasons or for other motives. It is therefore essential to define clearly the relations between them and the type of administrative agreement necessary to avoid future points of conflict. Nothing is more harmful to a project than a conflict arising over the respective powers of the public institutions participating in it. Once the size of the contributions to be made by one or more governmental bodies has been fixed and the delivery dates settled, it will still be necessary to make specific provisions for ensuring that the funds are received in the amount, type of currency and on the date laid down, and for deciding what type of enterprise will administer them.

The availability of the total amount of financial resources may depend on administrative questions related to the negotiation and approval of fiscal, municipal or federal budgets, as well as on the existing legal mechanisms governing, *inter alia,* the issue of bonds for external debts and credit operations with banks in general or the Central Bank in particular. For example, external credits—although approved in principle—will necessitate a series of administrative negotiations, in which governmental offices intervene which, in the first instance, have had little or nothing to do with the project.[25] Foreign credits are often granted upon State security, which leads to a number of special administrative requirements. It also frequently occurs that, for the opening of credit lines or payment of quotas abroad, specific arrangements have to be undertaken for obtaining the authorization of a body supervising international exchange, or the timely inclusion of such sums in a foreign exchange budget.

In all such cases, the speed and promptitude with which these problems are attended to and solved will generally depend on the thoroughness of their study in the initial phase of the project. Although nothing will have been stated in specific terms, the problems foreseen in this respect should at least be clearly pointed out, and an indication given in the work programme of the relevant negotiations to be put through or, at most, carried forward as far as possible. A well-studied project of high social priority may be delayed—and even ruined—by simple but unforeseen bureaucratic complications, or difficulties anticipated but not resolved in due time. It must be remembered that a hold-up in construction activities unnecessarily extends the period of maturity for investments, raises costs and finally, because of inter-industrial relations, impedes other developments connected with the project.

[25] The case of the Ministry or Secretariat of Foreign Affairs would be a typical one.

It is clear that projects in the public sector should enjoy as much administrative and financial flexibility as those in the private sector, to enable them to adjust themselves to any contingencies that may arise, both in construction and in operation. This involves a problem of systematization and adoption of suitable legal provisions, the solution of which often requires the drafting of special statutes, approved by Act or decree, which should be given due consideration—at least in outline—during the study phase of the project.

The aforementioned aspects are the most important from the standpoint of the public sector. Other problems connected with the organization and execution of the project are alike for the public and private sectors.

### 3. *Administrative capacity*

Apart from all the provisions and recommendations that may reasonably be incorporated in the project with regard to its organizational and executive stage, there remains one basic condition for success, and that is the presence of an efficient administrative staff. In this respect, a good project study will contribute to the success of the enterprise by presenting a set of well-considered and thoroughly coordinated plans and work schedules to the administrator responsible for their execution. The selection of well-qualified staff for the organization and establishment of the enterprise should receive as much attention as the project study itself.

## ILLUSTRATIVE CASES

### *Case 42*

### STUDY OF SOURCES AND USES OF CAPITAL IN A CEMENT PLANT PROJECT

This case is taken from a project for a cement plant at Pacasmayo, Peru.[1] An explanation will be given here of the manner in which a sources and uses table was used to demonstrate that the enterprise could develop normally, and service the foreign loans involved in the project.

The total investment was 100 million soles, two thirds in foreign currency, and one third in national. The foreign loan would be 2.5 million dollars—the equivalent of 500 million soles—for a period of 15 years, with 2½ years' grace, and 4.75 per cent interest. A selling price of 360 soles per ton of cement was assumed, and a production cost shown during the market study of this same project.[2]

A sources and uses table was prepared on the basis of the above data,[3] to demonstrate the financial stability of the enterprise (see table 108). The table is divided into four main headings: I. Profits, II. Source of capital, III. Application of capital, and IV. Guarantee of service of the debt. The period covers the three construction years and the first six of operation.

The first operating year would be 1958, but the enterprise would not be working at full capacity, so that costs and income would be less than in succeeding years. According to current laws, tax exemption will be granted during the first three years, and the net profits after taxes and interest will therefore be 10.5 millions in 1960 and 8.6 millions in 1961. The interest under this heading is that on the loan, and decreases as this latter is amortized. The other part of the service of the credit is that called "Loan repayment IBRD" under heading III.[4]

The net returns are next expressed as percentages of equity capital and of total investment.[5] Finally the ratio is given between net profits and the interest which must be paid to the Bank. It is seen, for example, that the former are 4.5 times greater than the latter.

The first item under heading II, "Availability at the beginning of the period" is the same as the last item under heading III, "Availability at the end of the period", but carried forward one year. Thus the surpluses from application of capital in 1955 are those which remain available as sources of capital in 1956. The share capital, that is, the equity capital of the enterprise, would be paid up in 1955, the first year of the installation of the plant, and the foreign loan would be used throughout the three construction years. The final item of II is net profits, after paying taxes, interest and amortization; this latter in turn represents liquid assets, as seen from the text, and it is therefore included as a source of capital. The table shows clearly the two periods of sources of capital: the installation period, when the capital consists of contributions from equity capital and loans, and the operating period when the sources are the balances of the previous period and the year's gross profits, that is, including reserves for sinking fund.

The first item under heading III covers the expenses of construction of the plant, including interest during this period, which is therefore assumed to have been actually paid out. The land and preliminary expenses—studies and others—are assumed to have been paid during the first year. The following items are those covering the use of capital during the operation period: repayment of the foreign debt—increasing amortization quotas which, added to the decreasing interest payments give a constant annual sum for service of the debt—and payment of dividends equal to 10 per cent of the equity capital. The difference of the totals under II and III constitutes the availability mentioned earlier, at the end of the period. It may be seen that this sum increases, so that by 1963, 33 million would already be available.

Heading IV shows the degree of security there would be for the service of the debt; these figures only cover the operating period. The first line, "Assets available for the service", represent net profits—after payment of taxes, but not interest—and the reserve for sinking fund. Comparing this amount with the total sum for service, which has been seen to be 5.2 millions per year, it may be appreciated that the assets available to meet the Bank commitments will be almost trebled (2.8) in the years when there is no longer any tax exemption, and more than trebled in 1959 and 1960.

The enterprise's financial situation as regard its debtor position was also presented in the form of *pro forma* balance sheets; table 109 shows these for 1957 and 1963. The ratio between the enterprise's total assets and the pending long-term debt would increase from 2.0 to 3.4, that

[1] See cases 8 and 31.
[2] See case 8.
[3] Also called origin and application.
[4] Note that the sum of interest and loan repayment is constant, since it was calculated by the formula for the sinking fund.
[5] For the calculation of net return, see Part Two, chapter III. Note also the considerable effect of tax exemption, showing the possibilities of this stimulus.

**Table 108**

CASE 42. ESTIMATE OF PROFITS, SOURCE AND APPLICATION OF CAPITAL, AND GUARANTEE OF SERVICE OF THE DEBT, 1955-1963[a]

*(Millions of soles)*

| | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|---|
| I. *Profits*: | | | | | | | | | |
| Sale of 100 000 tons[b] | | | | 28.8 | 36.0 | 36.0 | 36.0 | 36.0 | 36.0 |
| Direct cost | | | | 10.7 | 13.4 | 13.4 | 13.4 | 13.4 | 13.4 |
| Indirect cost | | | | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 |
| Depreciation (linear) | | | | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 |
| Director's fees | | | | 0.4 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| | | | | 20.4 | 23.4 | 23.4 | 23.4 | 23.4 | 23.4 |
| Net profits before taxes and interest | | | | 8.4 | 12.6 | 12.6 | 12.6 | 12.6 | 12.6 |
| Taxes (exemption for first three years) | | | | — | — | — | 2.1 | 2.1 | 2.2 |
| Interest | | | | 2.3 | 2.2 | 2.1 | 1.9 | 1.8 | 1.6 |
| Net profit after deducting taxes and interest | | | | 6.1 | 10.4 | 10.5 | 8.6 | 8.7 | 8.8 |
| Net profit (percentages of equity capital) | | | | 12.2 | 20.8 | 21.0 | 17.2 | 17.4 | 17.7 |
| Net profit (percentages of total investment) | | | | 6.1 | 10.4 | 10.5 | 8.6 | 8.7 | 8.8 |
| Ratio between net profit and interest to be paid to the International Bank | | | | 2.6 | 4.7 | 5.0 | 4.5 | 4.8 | 5.5 |
| II. *Sources of capital*: | | | | | | | | | |
| In hand at beginning of period[c] | — | 29.5 | 15.0 | 4.4 | 6.8 | 13.3 | 19.8 | 24.2 | 28.6 |
| Paid-up share capital | 50.0 | — | — | — | — | — | — | — | — |
| IBRD loan for construction | 15.0 | 25.0 | 10.0 | — | — | — | — | — | — |
| Net profit plus depreciation after taxes | — | — | — | 10.2 | 14.5 | 14.6 | 12.7 | 12.8 | 12.9 |
| Total sources | 65.0 | 54.5 | 25.0 | 14.6 | 21.3 | 27.9 | 32.5 | 37.0 | 41.5 |
| III. *Application of capital*: | | | | | | | | | |
| Construction of plant: | | | | | | | | | |
| Payments in foreign currency (using IBRD loan) | 15.0 | 25.0 | 10.0 | — | — | — | — | — | — |
| Payments in national currency | 8.0 | 8.0 | 6.6 | — | — | — | — | — | — |
| Other payments in foreign currency | 5.0 | 5.0 | 3.4 | — | — | — | — | — | — |
| Interest during construction | 1.5 | 1.5 | 0.6 | — | — | — | — | — | — |
| Purchase of land and mining deposits | 5.0 | — | — | — | — | — | — | — | — |
| Preliminary expenses | 1.0 | — | — | — | — | — | — | — | — |
| Payment IBRD loan | — | — | — | 2.8 | 3.0 | 3.1 | 3.3 | 3.4 | 3.6 |
| Payment of dividends (10 per cent) | — | — | — | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Total application | 35.5 | 39.5 | 20.6 | 7.8 | 8.0 | 8.1 | 8.3 | 8.4 | 8.6 |
| Available at end of period[d] | 29.5 | 15.0 | 4.4 | 6.8 | 13.3 | 19.8 | 24.2 | 28.6 | 32.9 |
| IV. *Guarantee of service of debt*: | | | | | | | | | |
| Cash availability for service[e] | — | — | — | 12.5 | 16.7 | 16.7 | 14.6 | 14.6 | 14.5 |
| Ratio between cash availability and total service of debt | — | — | — | 2.4 | 3.2 | 3.2 | 2.8 | 2.8 | 2.8 |

[a] Based on a selling price of 360 soles per ton.
[b] Except in 1958, the first year of plant operation.
[c] See last item "Application of capital".
[d] See first item "Source of capital".
[e] Sum of net profits on taxes (not interest) and of depreciation reserves.

is, the guarantee of the debt would increase by 70 per cent. This is partly due to the reduction of the debt—from 50 to 30.8 million—and partly because the assets would increase, as shown in table 108.

### *Case 43*

### SOURCES AND USES STUDY IN A RAILWAY PROJECT

It may again be appreciated from this case how the investment schedule is combined with the annual income and expenditure budget to produce a cash sources and uses table, and to show that it will be possible to meet both the service of the debt and the enterprise's normal development demands. The general structure of the table is the same as in the case of the cement plant, but the technical nature of the project, and its specific circumstances, cause some variations.

The investment schedule for the *Ferrocarril del Pacifico* rehabilitation programme (case 17) is already known.[6]

[6] This described the rehabilitation programme and the investments in national and foreign currency, itemized by years.

**Table 109**

CASE 42. *PRO FORMA* BALANCE SHEET

*(Millions of soles)*

| | 13 December 1957 | 13 December 1963 |
|---|---|---|
| *Assets*: | | |
| Original fixed assets (at cost) | 95 600 | 95 600 |
| Less amortization | — | 24 600 |
| Net value of original assets | 95 600 | 71 000 |
| Other assets (see "Available at end of period", table 108) | 4 400 | 32 900 |
| Total assets | 100 000 | 103 900 |
| *Liabilities*: | | |
| IBRD debt (long-term) | 50 000 | 30 800 |
| Equity capital | 50 000 | 50 000 |
| Reserves and retained profits | — | 23 100 |
| | 100 000 | 104 500 |
| Ratio between total assets and pending long-term debt | 2.0 | 3.4 |

The estimated annual income and expenditure budget is shown in table 110. For the present purpose, it is sufficient to show the results for the base year 1953, and for 1969, the last projected year. Note (i) shows the expected deficit for the years 1955 to 1958, not included in the table, which will be used later to explain the sources and uses plan (table 111).

Items I to VI of table 110 are conventional and require no further explanation. In this case, item VII, covering the characteristic coefficients of railway economic studies, demands greater attention. These are called "operating ratios"; they are expressed in percentages, obtained by dividing the various groups of expenditure by total income. They therefore show what percentage of total income is absorbed by the different items, or by total expenditure.

Table 110 also shows the significant difference between 1953, representing current conditions, and 1969, when the programme is in full operation. The total of 113.9 per cent in 1953—income did not cover expenses—would fall to 65.9 in 1963, which means that in the latter year there would be a surplus income of approximately 34 per

**Table 110**

CASE 43 ESTIMATE OF INCOME AND EXPENDITURE[a]

*(Thousands of pesos)*

| | 1953[b] *(true)* | 1969[a] |
|---|---|---|
| I. *Income*: | | |
| 1. Freight | 108 072 | 212 291 |
| 2. Passengers | 16 894 | 15 632 |
| 3. Parcels express | 6 129 | 5 182 |
| 4. Others[c] | 8 780 | 15 431 |
| 5. Miscellaneous[d] | — | 24 854 |
| Total | *139 875* | *273 390* |
| II. *Expenses*: | | |
| 1. Track maintenance | 32 458 | 51 159 |
| 2. Equipment maintenance | 35 823 | 36 533 |
| 3. Transport | 75 403 | 54 295 |
| 4. Others[e] | 15 670 | 19 843 |
| Total | *159 354* | *161 830* |
| III. *Net operating income* | *—19 479* | *111 560* |
| 1. Net payments for hire of equipment[f] | 15 137 | 18 674 |
| 2. Miscellaneous taxes[g] | 801 | 1 243 |
| IV. *Net total income* | *—35 417* | *91 643* |
| Losses other than operation[h] | —1 704 | —1 519 |
| V. *Net income before deducting overhead* | *—37 121* | *90 124* |
| Overhead | 2 140 | 5 750 |
| VI. *Final net income of loss*[i] | *—39 261* | *84 374* |
| VII. *Operating ratios based on total income, excluding item I-5*: | | |
| 1. Track maintenance | 23.2% | 20.6% |
| 2. Equipment maintenance | 25.6% | 14.7% |
| 3. Transport | 53.9% | 21.8% |
| 4. Total | 113.9% | 65.9% |

[a] Adjusted for devaluation of peso (19 April 1954) and 10 per cent general wage increase (1 June 1954).
[b] These figures are from the report, recalculated at present worth, and represent the true result of operations in 1953. The figures in case 2 on projection of traffic, are estimates for 1953, taken as a basis for the projection. The differences were not important.
[c] Includes postal and unclassified miscellaneous items.
[d] 10 per cent tax on gross income, which the government agrees may be regarded as income.
[e] Various miscellaneous expenses.
[f] Mainly payments for the use of other companies' wagons.
[g] A number of small taxes.
[h] Losses in the branch-line station.
[i] Original table of annual figures, showing losses as follows: 1955: —36 400; 1956: —26 163; 1957: —18 325; 1958: —11 147.

## Table 111

CASE 43. SOURCES AND USES OF CAPITAL, 1955-65[a]

*(Thousands of pesos)*

| | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cash requirements:* | | | | | | | | | | | |
| To cover deficit[b] | 36 400 | 26 163 | 18 325 | 11 147 | — | — | | | | | |
| Investments according to programme: | | | | | | | | | | | |
| In national currency | 30 498[c] | 30 786 | 17 992 | 4 600 | — | 25 575[d] | 21 313[d] | 25 575[d] | — | 21 313[d] | — |
| In foreign currency | 188 976[c] | 184 350 | 177 300 | 25 313 | — | — | | | | | |
| Amortization of debt: | | | | | | | | | | | |
| Eximbank | 6 250 | 6 250 | 6 250 | 6 250 | 6 250 | 6 250 | 6 250 | 6 250 | 6 250 | — | — |
| New 61 million loan | — | — | | | 29 470 | 38 125 | 38 125 | 38 125 | 75 000 | 75 000 | 75 000 |
| Total | *262 124* | *247 549* | *219 867* | *47 310* | *35 720* | *69 950* | *65 688* | *69 950* | *81 250* | *96 313* | *75 000* |
| *Cash availability from own sources:* | | | | | | | | | | | |
| From charges for track maintenance | 32 466 | 32 466 | 32 466 | 31 751 | 31 751 | 23 898 | 23 898 | 23 898 | 23 898 | 23 898 | 19 973 |
| From amortization charges: | | | | | | | | | | | |
| Track | 2 994 | 2 994 | 2 994 | 2 994 | 2 994 | 2 994 | 2 994 | 2 994 | 2 994 | 2 994 | 2 994 |
| Equipment | 8 539 | 10 564 | 9 608 | 9 949 | 10 956 | 9 783 | 9 783 | 10 635 | 11 346 | 12 199 | 10 580 |
| Sale of discarded material | 1 578 | 2 058 | 2 058 | 2 413 | 1 923 | 1 923 | 1 208 | 1 353 | 143 | 533 | 533 |
| Net income surplus after deducting overhead | — | — | — | — | 1 897 | 15 048 | 23 838 | 30 093 | 36 947 | 46 782 | 55 238 |
| *Available from loans:* | 188 976 | 184 350 | 177 300 | 25 313 | | — | — | | | | |
| Government contributions | 27 571 | 15 117 | — | — | — | — | — | | | | |
| Total | *262 124* | *247 549* | 224 426 | 72 420 | *49 521* | *53 646* | *61 721* | *68 973* | *75 328* | *86 406* | *89 318* |
| Available surplus | — | — | 4 559 | 25 110 | 13 801 | —16 304 | —3 967 | —977 | —5 922 | —9 907 | 14 318 |
| Accumulated available surplus | — | — | 4 559 | 29 669 | 43 470 | 27 166 | 23 199 | 22 222 | 16 300 | 6 393 | 20 711 |

[a] Estimated.
[b] See table 110.
[c] Does not include 66 523 pesos expenses in 1954.
[d] Covers 1 100 wagons to be purchased in 1960-64.

cent after covering operating costs. The lowering of the operating ratio is especially notable in transport, where it falls to less than half.

Table 111 also covers the period 1955-1969, but for demonstration purposes it is sufficient to show the development up to 1965. Three main groups of figures can be seen in the plan—"cash requirements", "liquid assets" and "available surplus". The first item amongst the requirements is the previously-noted deficit, indicated by table 110 for the years 1955 to 1958. Next are the investments according to the programme, including the purchase of wagons between 1960 and 1964, and the amortization of the debt, both the Export-Import Bank credit and the new loan being negotiated with the International Bank. Note that service on the latter would commence in 1959, after completion of the rehabilitation programme.

The "availabilities" mainly come from income as shown in table 111. Since the annual operating deficit was included in the requeriments, suplus income as from 1959 is now shown amongst the availabilities, according to the annual estimates of income and expenditure. The second source is foreign loans which have been requested, and which would be received, according to the development programme, in 1955 and 1958.[7] The third source comprises government contributions promised for 1955 and 1956, which will be exactly enough to balance the accounts, so that availabilities will be sufficient to cover requirements. As from 1957 there would be an "available surplus", without further need for contributions from the public sector. This surplus would gradually accumulate, and would be used later to cover the purchase of wagons projected for 1960-1964. During this period the availabilities would not meet the requirements, but the difference is more than covered by the accumulated surpluses, and therefore no government assistance will be necessary.

The notable differences between this sources and uses table and that for the cement plant lie in the inclusion of the item "government contributions", which are possible in this case of a State enterprise, and the postponement of the purchase of wagons until such time as it could be financed by the enterprise's own funds. This postponement is based on the possibility of operating with the minimum number of new wagons, and repairing old ones to meet traffic requirements. An investment schedule does not always have the advantage of such flexibility.

### *Case 44*

### Analysis of the influence of electricity rates in the financing of the Chilean electrification programme

A summary in given below of the analysis made in the Chilean electrification programme in relation to the influence which rate variations may have on the financing of this programme.[8]

The financing schedule for 1953-1954 may be summarized as shown in Table 112.

As may be seen, the financing problem is presented in terms of the total cash movement which the enterprise would have during the period of the programme. The

[7] It has already been mentioned that service of these credits would commence in 1959.

[8] Other aspects of the Chilean electrification programme have been used as examples for forecasting of demand (case 3) and the choice of technical alternatives (case 15).

**Table 112**

CASE 44. FINANCING PLAN, 1953-64

*(Millions of pesos)*

| | *Total for the period* | |
|---|---|---|
| I. Earned income[a] | 20 925 | |
| II. States contributions[b] | 24 003 | |
| *Total cash income* | | 44 928 |
| III. Normal expenses[c] | 15 552 | |
| IV. Investments according to programme | 29 376 | |
| *Total cash expenditure* | | 44 928 |

*Source*: ENDESA, *op. cit.*

[a] Includes nearly 18 000 millions operating income, plus contributions from third parties and other income.

[b] Includes foreign loans obtained for electrification and reinvestment of interest and dividends.

[c] Includes payment of interest and dividends (which will be reinvested).

income therefore includes normal operating income and State contributions, with possible foreign loans included in the latter. In the same way, expenditure includes all normal operating expenses and investment in the programme. This includes re-investment of all profits and reserves due to the public sector on account of previous investments.

Contributions from the public sector could be considerably reduced if the rates were adjusted to a minimum true net return. According to the general law governing electrical services in Chile *(Ley General de Servicios Eléctricos)* the net profit of a public utility concession must not be greater than 15 per cent nor less than 10 per cent of the fixed capital, after paying operating expenses and setting aside adequate reserves for depreciation. The State electricity enterprise's problem is that its cash requirements to meet expenses and investments increase yearly according to the inflation index, without the possibility of parallel adjustment of the rates of the primary systems. This has led to an extraordinary disequilibrium between the net operating income in a given year and the sum of operating expenses plus the service of capital already involved in the works, revalued at the prices of the year in question.

To analyse the effect of setting the rates at a minimum true level, within the existing profits laws, investments made up to 31 December 1952 were calculated at present worth at 1953 prices, and the annual investments according to the 1953-1954 programme were added, these latter being expressed in constant values, also at 1953 prices. From this total was subtracted that part covering works still in progress—which it was assumed still showed no profit—thus obtaining the present worth of the investment, year by year, in "operating works". It was assumed that these works had a gross operating income of 6 per cent on capital—calculated as above—plus 2.5 per cent amortization, plus operating expenses estimated in the programme. The result of these calculations is shown in table 113.

With the assumed net return, the minimum total income would be nearly 29 000 million pesos, as against the 18 000 million calculated on the basis of the present rates.[9]

It may be seen, therefore, that the adjustment of the electricity rates to a reasonable minimum level would alone be sufficient to increase income by some 10 000 million pesos. Maintaining the criterion of reinvestment of the government's dividends and interests these increases

[9] See note [a] of table 112.

Table 113

CASE 44. GROSS OPERATING INCOME FOR SELECTED YEARS, ASSUMING ASSETS CALCULATED AT PRESENT WORTH[a]

*(Millions of pesos at 1953 prices)*

| Year | Total cumulative investment A | Cumulative investment in "works in progress" B | Cumulative investment in "operating works" A — B | Gross minimum annual operating income with 6 per cent net profit |
|---|---|---|---|---|
| 1953 | 11 500 | 3 500 | 8 000 | 954 |
| 1960 | 27 400 | 4 200 | 23 200 | 2 724 |
| 1964 | 39 900 | 4 600 | 35 300 | 4 048 |

*Source*: ENDESA: *op. cit.*
[a] The original study gave the detail for all years.

in income would be available for the development programme. Accordingly, the new cash contributions which the *Corporación de Fomento*—which represents the public sector in this case—would have to make would be 11 253 million pesos, an amount almost equal to the increased income which could be obtained from reasonable rates.

If the net profit were raised from 6 to 7 per cent, some 2 500 millions more would be obtained, which would almost completely pay the interest and amortization on foreign loans included in the financing scheme during the programme. Consequently an adjustment of rates would make new public contributions to the development programme unnecessary.

This case clarifies a very important political-economic problem: that of the relation between the rates of State-owned public utility enterprises and the taxation system. The alternative in the present instance is clear: either the rates are adjusted, and State contributions to electrification are reduced in the same proportion, or they are not adjusted, and State contributions continue. Since State enterprises are involved, the community must contribute to their financing in one of the three following ways:

(1) By paying the additional taxes required to finance that part of the national budget allocated to electrification works;

(2) By paying the consequences of the increased prices resulting from inflationary effects, by financing the works through currency issues; or

(3) By paying the contributions directly in the form of higher rates.

These three methods of payment vary in their economic consequences, and have different effects on the various sectors of the community.

A good taxation system may place the burden of the charges on those sectors which can best carry it. This would result in capital formation in the public sector at the expense of specific private sectors. The solution can be satisfactory, provided that it meets at least two basic conditions: (*a*) that the taxation system is sufficiently efficient to ensure collection of the desired amount, and from the desired sectors, and (*b*) that the transfer truly implies greater domestic capital formation and that under no circumstances does it involve the postponement of investments which the sectors concerned would otherwise have

Table 114

CASE 45. SOURCES AND USES OF FUNDS FOR A PROJECT TO MANUFACTURE

| | *1956* | *1957* | *1958* | *1959* | *1960* | *Total* |
|---|---|---|---|---|---|---|
| I. *Sources* | | | | | | |
| 1. Loans: | | | | | | |
| (*a*) External | — | 177 227 685 | 225 040 410 | — | — | 402 268 095 |
| (*b*) Local | — | 40 000 000 | 40 000 000 | — | — | 80 000 000 |
| 2. Own resources: | | | | | | |
| (*a*) Reserves held by the enterprise itself[a] | 33 176 116 | 47 445 000 | 20 690 495 | 43 941 251 | 14 634 916 | 159 887 778 |
| (*b*) Increase in capital | 61 200 000 | 20 000 000 | 80 000 000 | 80 000 000 | — | 241 200 000 |
| (*c*) Reinvestment[b] | — | — | 25 100 505 | 60 218 749 | 35 153 084 | 120 472 338 |
| 3. Total resources (1+2) | 94 376 116 | 284 672 685 | 390 831 410 | 184 160 000 | 49 788 000 | 1 003 828 211 |
| II. *Uses* | | | | | | |
| 1. Land | 12 449 316 | — | — | — | — | 12 449 316 |
| 2. Construction | 3 700 000 | 41 596 000 | 33 120 000 | 49 160 000 | — | 127 576 000 |
| 3. Plant | 1 800 000 | 15 000 000 | 18 061 000 | 12 000 000 | — | 46 861 000 |
| 4. Equipment: | | | | | | |
| (*a*) Domestic | 1 500 000 | 35 804 000 | 51 819 000 | 82 440 000 | — | 171 563 000 |
| (*b*) Imported | 74 926 800 | 177 227 685 | 225 040 410 | — | — | 477 194 895 |
| 5. Total fixed investment (1+2+3+4) | 94 376 116 | 269 627 685 | 328 040 410 | 143 600 000 | | 835 644 211 |
| 6. Circulating capital | — | 15 045 000 | 62 791 000 | 40 560 000 | 49 788 000 | 168 184 000 |
| 7. Total capital | 94 376 116 | 284 672 685 | 390 831 410 | 184 160 000 | 49 788 000 | 1 003 828 211 |
| 8. Total accumulation of capital | 94 376 116 | 379 048 811 | 769 880 211 | 954 040 211 | 1 003 828 211 | |

[a] This source includes resources accumulated in the enterprise's other activities and funds alloted for amortizing the project, as may be seen from the credit balance in table 109 which shows the flow of sources and uses of funds during operation.
[b] Originating from undistributed profits.

made with these same resources. Opinion is almost unanimous that the inflationary form of financing is undesirable, because of its effects.

Amongst the advantages of financing through rates, the following may be mentioned: the system burdens those who use the service, and has a broad base because of the wide input use of electrical energy; the funds are obtained by direct collection, since they pass directly to the enterprise without State intervention; it offers the alternative of exchanging the increased rates for shares or profit-sharing certificates for the consumers, who—once the initial development stage is past—may receive a return; rates may be scaled in a way which appears to be the fairest socially (less for small consumers, for example), and finally, collection is certain.

At the same time, higher rates present certain difficulties. There may be considerable public resistance, since it is difficult to convince the public that they must pay by one or other alternative. Further, the increases raise production costs. Although electrical input represents a small percentage (with certain exceptions), its diversity in intermediate demand gives it a cumulative influence. It may be appreciated, therefore, that the problem goes beyond the specific enterprise, and becomes a matter of national economic policy. A clear presentation of the problem, when preparing the programme, will contribute towards the best possible solution.

In the Chilean case, the rate alternative was chosen, proposing that the government should pass a law on the following lines:

(1) *Annual* readjustment of rates, taking into account the greater operating expenses resulting from monetary devaluation, so that the net return on investment will be maintained at a level consistent with the true value of the capital.

(2) Surcharge of the rates for users of public utility services, to form a fund for financing expansions of these services.

(3) Customs franchise for equipment for primary electrical services.

### *Case 45*

### Tables of sources and uses of funds to explain methods of financing a project for the manufacture of lorry axles

The enterprise in question, which is already established and manufactures railway material, is planning to expand its plant in order to produce lorry axles. In the following example, only the tables of sources and uses of funds which accompany the project are given, since they outline the methods of financing proposed and indicate the liquidity of the enterprise over the years. These tables confirm the estimates of the enterprise's ability to service credits made in the financing schemes.

Total investment needed by the project would be 1 003.8 million according to the break-down in table 114, which shows that two basic sources of funds have been considered for the installation and operation of the project: (1) Loans (one from abroad and another from a local developments bank); and (2) the enterprise's own resources (reserves, capital increments and reinvestment of profits). These funds would be used to buy land, to construct buildings and plant and to purchase equipment in 1957-60, as indicated in the same table. Apart from financing fixed

**Table 115**

CASE 45. SOURCES AND USES OF FUNDS DURING THE OPERATION OF THE PROJECT FOR MANUFACTURING LORRY AXLES, 1957-68[a]

| Year | Invoicing | Costs | Profits subject to taxation (A—B) | Income tax | Liquid profits (C—D) | Interest and amortization of credits: External (F) | Interest and amortization of credits: Local (G) | Interest and amortization of credits: Total (F—G) (H) | Deficit (F—H) | Credit balance (E—H) | Total capital[b] | Capital balance (J/K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (A) | (B) | (C) | (D) | (E) | | | | (I) | (J) | (K) | (L) |
| 1957 | 26 930 000 | 22 219 380 | 4 710 620 | 471 162 | 4 239 458 | 7 503 830 | — | 7 503 830[c] | 3 264 372 | — | 379 048 801 | — |
| 1958 | 263 552 100 | 211 901 680 | 51 650 420 | 5 169042 | 46 485 378 | 17 384 873 | 4 000 000 | 21 384 873 | — | 25 100 505 | 769 880 211 | 3.3 |
| 1959 | 704 510 400 | 577 650 848 | 126 859 552 | 12 685 955 | 114 175 597 | 45 954 848 | 8 000 000 | 53 954 848 | — | 60 218 749 | 954 040 211 | 6.3 |
| 1960 | 1 144 278 300 | 1 009 588 890 | 134 689 410 | 13 468941 | 121 220 469 | 74 685 792 | 11 381 592 | 86 067 385 | — | 35 153 084 | 1 003 828 211 | 3.5 |
| 1961 | 1 481 939 400 | 1 174 333 170 | 307 606 230 | 30 760 623 | 276 845 607 | 94 316 180 | 14 763 185 | 109 079 365 | — | 167 766 242 | 1 003 828 211 | 16.7 |
| 1962 | 1 481 939 400 | 1 174 333 170 | 307 606 230 | 30 760 623 | 276 845 607 | 94 316 180 | 14 763 185 | 109 079 365 | — | 167 766 242 | 1 003 828 211 | 16.7 |
| 1963 | 1 481 939 400 | 1 174 333 170 | 307 606 230 | 30 760 623 | 276 845 607 | 94 316 180 | 14 763 185 | 109 079 365 | — | 167 766 242 | 1 003 828 211 | 16.7 |
| 1964 | 1 481 939 400 | 1 174 333 170 | 307 606 230 | 30 760 623 | 276 845 607 | 64 993 586 | 14 763 185 | 79 756 771 | — | 197 088 836 | 1 003 828 211 | 19.6 |
| 1965 | 1 481 939 400 | 1 174 333 170 | 307 606 230 | 30 760 623 | 276 845 607 | 26 381 599 | 14 763 185 | 41 144 785 | — | 235 700 823 | 1 003 828 211 | 23.4 |
| 1966 | 1 481 939 400 | 1 174 333 170 | 307 606 230 | 30 760 623 | 276 845 607 | — | 14 763 185 | 14 763 185 | — | 262 082 422 | 1 003 828 211 | 26.0 |
| 1967 | 1 481 939 400 | 1 174 333 170 | 307 606 230 | 30 760 623 | 276 845 607 | — | 14 763 185 | 14 763 185 | — | 262 082 422 | 1 003 828 211 | 26.0 |
| 1968 | 1 481 939 400 | 1 174 333 170 | 307 606 230 | 30 760 623 | 276 845 607 | — | 7 381 592 | 7 381 592 | — | 262 464 015 | 1 003 828 211 | 26.7 |

[a] The figures in this table refer only to the new project and not to the enterprise's other activities.
[b] See line 8 in table 114.
[c] Interest only. From 1958 onwards, amortization and interest were included on the basis of the figures in the special table showing liquidation of interest (see column H in table 116).

Table

CASE 45. DETAILS OF CREDIT SERVICING IN

| Year (A) | External loan: Amounts received: First loan (B) | Second loan (C) | Third loan (D) | Amortization and interest: First loan (E) | Second loan (F) | Third loan (G) |
|---|---|---|---|---|---|---|
| 1957 | | | | | | |
| First six months | 72 900 000.00 | — | — | 2 187 000.00 | — | — |
| Second six months | — | 104 327 685.00 | — | 2 187 000.00 | 3 129 830.50 | — |
| 1958 | | | | | | |
| First six months | — | — | — | 2 187 000.00 | 3 129 830.50 | — |
| Second six months | — | — | 225 040 410.00 | 2 187 000.00 | 3 129 830.50 | 6 751 212.30 |
| 1959 | | | | | | |
| First six months | — | — | — | 8 546 103.45 | 3 129 830.50 | 6 751 212.30 |
| Second six months | — | — | — | 8 546 103.45 | 12 230 386.67 | 6 751 212.30 |
| 1960 | | | | | | |
| First six months | — | — | — | 8 546 103.45 | 12 230 386.67 | 6 751 212.30 |
| Second six months | — | — | — | 8 546 103.45 | 12 230 386.67 | 26 381 599.78 |
| 1961 | | | | | | |
| First six months | — | — | — | 8 546 103.43 | 12 230 386.67 | 26 381 599.78 |
| Second six months | — | — | — | 8 546 103.43 | 12 230 386.67 | 26 381 599.78 |
| 1962 | | | | | | |
| First six months | — | — | — | 8 546 103.43 | 12 230 386.67 | 26 381 599.78 |
| Second six months | — | — | — | 8 546 103.43 | 12 230 386.67 | 26 381 599.78 |
| 1963 | | | | | | |
| First six months | — | — | — | 8 546 103.43 | 12 230 386.67 | 26 381 599.78 |
| Second six months | — | — | — | 8 546 103.43 | 12 230 386.67 | 26 381 599.78 |
| 1964 | | | | | | |
| First six months | — | — | — | — | 12 230 386.67 | 26 381 599.78 |
| Second six months | — | — | — | — | — | 26 381 599.78 |
| 1965 | | | | | | |
| First six months | — | — | — | — | — | 26 381 599.78 |
| Second six months | — | — | — | — | — | |
| 1966 | | | | | | |
| First six months | — | — | — | — | — | |
| Second six months | — | — | — | — | — | |
| 1967 | | | | | | |
| First six months | — | — | — | — | — | |
| Second six months | — | — | — | — | — | |
| 1968 | | | | | | |
| First six months | — | — | — | — | — | |
| Second six months | — | — | — | — | — | |

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THE MANUFACTURE OF LORRY AXLES, 1957-68

| Annual total (H) | Local loan: Amounts received: First loan (I) | Local loan: Amounts received: Second loan (J) | Local loan: Amortization and interest: First loan (K) | Local loan: Amortization and interest: Second loan (L) | Local loan: Annual total (M) | Annual total foreign and local (N) |
|---|---|---|---|---|---|---|
| 7 503 830.50 | —<br>— | —<br>— | —<br>— | —<br>— | | 7 503 830.50 |
| 17 384 873.30 | 40 000 000.00<br>— | —<br>— | 2 000 000.00<br>2 000 000.00 | —<br>— | 4 000 000.00 | 21 384 873.30 |
| 45 954 848.67 | —<br>— | 40 000 000.00<br>— | 2 000 000.00<br>2 000 000.00 | 2 000 000.00<br>2 000 000.00 | 8 000 000.00 | 53 954 848.67 |
| 74 685 792.32 | —<br>— | —<br>— | 3 690 796.40<br>3 690 796.40 | 2 000 000.00<br>2 000 000.00 | 11 381 592.80 | 86 067 385.12 |
| 94 316 179.80 | —<br>— | —<br>— | 3 690 796.40<br>3 690 796.40 | 3 690 796.40<br>3 690 796.40 | 14 763 185.60 | 109 079 365.40 |
| 94 316 179.80 | —<br>— | —<br>— | 3 690 796.40<br>3 690 796.40 | 3 690 796.40<br>3 690 796.40 | 14 763 185.60 | 109 079 365.40 |
| 94 316 179.80 | —<br>— | —<br>— | 3 690 796.40<br>3 690 796.40 | 3 690 796.40<br>3 690 796.40 | 14 763 185.60 | 109 079 365.40 |
| 64 993 586.16 | —<br>— | —<br>— | 3 690 796.40<br>3 690 796.40 | 3 690 796.40<br>3 690 796.40 | 14 763 185.60 | 79 756 771.76 |
| 26 381 509.78 | —<br>— | —<br>— | 3 690 796.40<br>3 690 796.40 | 3 690 796.40<br>3 690 796.40 | 14 763 185.60 | 41 144 785.38 |
| —<br>— | —<br>— | —<br>— | 3 690 796.40<br>3 690 796.40 | 3 690 796.40<br>3 690 796.40 | 14 763 185.60 | 14 763 185.60 |
| —<br>— | —<br>— | —<br>— | 3 690 796.40<br>3 690 796.40 | 3 690 796.40<br>3 690 796.40 | 14 763 185.60 | 14 763 185.60 |
| —<br>— | —<br>— | —<br>— | —<br>— | 3 690 796.40<br>3 690 796.40 | 7 381 592.80 | 7 381 592.80 |

investment, the funds would also be adequate to cover circulating capital requirements from 1957 onwards.

Table 115 shows sources and uses of funds during the enterprise's period of operation from 1957 to 1968. In the original study, this table was entitled the enterprise's "state of liquidity". (Strictly speaking, the degree of liquidity would be greater than indicated in the table, since the costs column includes charges for depreciation reserves as well.)

Column J in table 115 gives the annual credit balance obtained after production costs, income tax and the servicing of credits included in the sources in table 114 have all been deducted from sales. Column K shows the total capital in use each year (obtained from table 114) and, lastly, column L indicates the balance/capital ratio, as a percentage.

Table 116 breaks down the calculations made for columns F, G and H in table 115. The external loan is assumed to be some 402.3 million, of which 72.9 would be received in the first half of 1957, 104.3 in the second half and 225 (in round figures) in the second half of 1958. An annual interest rate of 6 per cent would be charged, and amortization of the loan would not begin until 1959, interest only being paid in 1957 and 1958. Columns E, F and G in the same table show how the servicing of the three external credits enumerated in columns B, C and D proceeded. Column H refers to the total annual servicing of these credits. The local loan would be given in two instalments of 40 million in the first six months of 1958 and 1959, as indicated in columns I and J. The interest rate would be 10 per cent annually, and amortization would not begin until 1960 and 1961 for the credits granted in 1958 and 1959 respectively.

During the first two years after receipt of each quota, interest only would be paid. Column M shows the annual total required for servicing local credit and column N, the total servicing of both external and local loans. These figures have been carried over to columns G and H in table 115.

Credits would be serviced every six months. This means that, in order to calculate the capital recovery coefficient, two figures must be selected from the financial tables which correspond to 10 periods and 3 per cent in the case of the foreign loan and to 16 periods and 5 per cent in the case of the local loan. (This corresponds to a term of 5 years at 6 per cent for the former and 8 years at 10 per cent for the latter.) The coefficients taken from the tables are 0.11723 and 0.099227 for the external and internal credits respectively. If these values are multiplied by the different credit quotas (columns B, C, D, I and J, in table 116), the total amount of servicing (amortization and interest) can be estimated for each quota (columns E, F, G, K and L in the same table).

## Chapter VIII

## SUMMARY AND PRESENTATION OF THE PROJECT

### I. Summary

High executives who are responsible for decisions or expression of opinions on projects usually have little time to examine all the material submitted for their consideration, and are not always in a position to appreciated the technical details of the studies. On the other hand, they will have public or private business experience, and a sound critical judgement, and will have expert advice available in the various special fields. It is as well, therefore, to sumarize the project so as to simplify the formation of an over-all opinion, without any need to study all the various parts. The chapters which follow the summary of the project, together with the annexes, will allow the technical advisors to verify the figures, the quality of the data employed in the study, the accuracy of the criteria, or the nature of the inevitable estimations which will arise in the formulation of any project. The details will also be of interest to those who have to establish priorities and evaluate the project. Finally—and this is not a point of minor importance—it must be remembered that the details will be of the greatest use to those who must finish the studies for execution, and who must carry out certain tasks already foreseen in the planning stage relating to organization, administration, official relations, legal problems and so forth. Nevertheless, knowledge of details is not required in order to obtain a first general appreciation and this should therefore be simplified by the preparation of a summary which contains the basic conclusions, and which describes the project's more significant aspects.

As for the presentation of the summary, it will be useful to begin by explaining, in the first two or three pages, the essence of the project, that is, to summarize the summary. It will be a kind of memorandum with the following details:

(a) *Aims of the project,* with information on the volume and type of goods and services which it is proposed to produce, and the volume of demand which justifies their production.

(b) *Location of the project.*

(c) *Investments in the project,* with the figures of the fixed investment, working capital, and the composition of the capital in national and foreign currency.

(d) Final figures of the expenditure and income, for one year of normal production, and at market prices.[1]

(e) *Profitability of the project,* computed from the point of view of the entrepreneur, and compared with the current market interest rates.[2]

(f) *Social evaluation of the project,* offering simply a series of evaluation coefficients, and indicating freely the criteria on which they are based.[3]

(g) *Financing sources.*

This schematic data should be followed by an extract of the most important parts of each chapter, thus providing an abbreviated version of the project. The summary must be limited to matters dealt with in the text, and must not include any additional data. A few simple plans and diagrams may assist the explanations. This summary should not exceed 20 to 25 pages of double-spaced type.

[1] Unit production cost figures will also be given, and some equalization points which are considered to be of interest (for instance, the minimum percentage of installed capacity which must be employed in order to avoid losses; variations in prices of input or output which the enterprise could accept without incurring losses).

[2] These subjects, and those of point (f), are dealt with in Part Two.

[3] For example, value added and labour employed per unit of investment; ratio between income and costs, priced socially; value added per unit of total resources, etc.

### II. Presentation

The presentation of the subject matter of a project may take one of several equally satisfactory forms. The order and form of presentation will depend upon the personal preference of the project-maker, on the nature of the project, on possible conventions in the country concerned, or standards established by the body to which the project is to be presented.

The order in which the various subjects have been presented in the first part of this *Manual* may also be followed in the presentation. Since the basic reason for the execution of projects is to satisfy some needs of the population, it appears logical to commence by establishing what these needs are as regards the goods or services concerned, that is, to commence with the market study. Two basic points should be remembered: (*a*) the great advantage of beginning the presentation with a summary of the chapters, as explained above; (*b*) the advisability of not overloading the text with details, arguments, statistics, analysis and partial studies which have been necessary in order to arrive at certain conclusions. An attempt must be made to discriminate between material which is essential to the contents and coherence, and that which is merely auxiliary, leaving the latter to be inserted in annexes or appendices. The presentation plan given below is not intended to set any standard form, but only to suggest a model which would serve not only as a presentation plan, but which would also assist in the organization of the early studies, and as a comparative guide, to check whether any points have been omitted.[4] Obviously, each general plan must be adapted to the type of project to which it refers, and to the circumstances of the study.

[4] Another presentation plan may be found in the document *Formulation and Economic Appraisal of Projects,* (ST/TAA/4). United Nations publication, Sales No.: 1951.II.B.4. vols. I and II. See especially vol. I, Part VI, pp. 419 *et seq* and the appendix, pp. 469 *et seq.*

## OUTLINE FOR PRESENTATION OF PROJECTS

CHAPTER I. *SUMMARY OF THE PROJECT*

1. *General presentation of the basic data of the project* (2 or 3 pages):

   (*a*) Goods or services to be produced, capacity to be installed, and total volume of demand;
   (*b*) Location;
   (*c*) Volume of investments;
   (*d*) Budget of expenditure and income (summarized); unit costs and equalization points;
   (*e*) Profitability;
   (*f*) Coefficients of social evaluations;
   (*g*) Sources of financing considered.

2. *Systematic and coherent extract of the contents of the remaining chapters* (about 20 pages). Simple and effective plans and diagrams (do not use partial plans).

CHAPTER II. *MARKET STUDY*

1. *General presentation of the market problem in relation to the specific project* (aspects of the general market study which are of special interest in the case).

2. *Compilation of data:*

   (*a*) Uses and specifications of goods or services;
   (*b*) Statistical series of production, imports, exports and consumption—national income and population;
   (*c*) Type and idiosyncrasies of the consumers;
   (*d*) Geographical distribution of the market; competitive nature of the market and marketing methods (prices and costs, present sources of supply of the market, distribution mechanisms, competitive goods and services);
   (*e*) Economic policy, and its effect on the goods or services being studied (tariffs, taxes, subsidies, price controls, rationing, etc.);
   (*f*) Possible demographic or structural changes in economic development.

3. *Establishmenet of the total current, true and apparent demand.*

4. *Conclusions and forecasts of the study as regards marketing of the goods or services.* (Points concerning sales organization and distribution methods, transport problems, methods of presentation of the product, possible technical servicing requirements for the users, possible advertising requirements, and other aspects.)

5. *Conclusions and forecasts of the study relating to the incidence of economic policy on the market.* (Suggested solutions of problems of price fixing, rationing, distribution or transport monopolies, tariff protection, tax exemption, subsidies, etc.)

6. *Projection of demand.*

CHAPTER III. *SIZE AND LOCATION*

1. *Justification of the proposed installed capacity, covering especially the following factors:*

   (*a*) Market, location, distribution;
   (*b*) Production techniques, and costs at the points of distribution;
   (*c*) Financing, and adaptability to staged installation.

2. *Justification of the location, considering essentially the following:*

   (*a*) Minimum freights; discussion as to whether the location of the new unit will be oriented towards the inputs or towards the market; geographical points which meet the condition of minimum freights;

(*b*) Availability and costs of resources, especially raw materials, labour, fuel and electric power, water and others;

(*c*) Other aspects of location, such as decentralization policy; administrative, housing, health, educational and other facilities, living conditions and climate;

(*d*) Relation between size, location and minimum delivery costs to the user;

(*e*) Explanatory diagrams and plans.

3. *Annexes.* The annexes will contain all details referring to rail and road distances, freight tariffs, zoning regulations and similar data.

## CHAPTER IV. *PROJECT ENGINEERING*

1. *Preliminary research and testing.* Patents.

2. *Technical alternatives. Selection and description of the production process;* flow diagrams; specifications of the required inputs.

3. *General description of the construction and operating equipment.*

4. *Buildings and their distribution on the site.* Explanatory diagrams.

5. *Plant layout.* Explanatory diagrams.

6. *Complementary engineering projects.* (Industrial and drinking water, housing for personnel, sanitary works, miscellaneous services.) Explanatory diagrams.

7. *Assumed productivity in the use of the resources.* (Estimated technical efficiency of the process, personnel required, etc.)

8. *Flexibility of productive capacity.* (Possibility of adapting to the production of different goods, expansion possibilities, incidence of output rate on costs, relation to the market.)

9. *Work schedule.* Final studies, transition stage, installation, entry into operation, and operation.

10. *Annexes.* The text will include the simpler diagrams and plans. The more detailed plans will be in the annexes, together with copies of specifications, laboratory reports and tests, patent details, detailed lists of personnel required and their technical qualifications, technical details on specifications of raw materials, fuels and similar. The annexes will also contain the more detailed data which justify the adoption of specific solutions as regards process, degree of mechanization, type of buildings, construction materials and technical alternatives in general.

## CHAPTER V. *INVESTMENTS*

1. *Composition and volume of fixed capital investments:*

(*a*) Cost of preliminary research, experiments and studies, including that of the project;

(*b*) Patents and similar items;

(*c*) Payment for land and natural resources;

(*d*) Cost of the equipment placed on site, and its installation;

(*e*) Cost of complementary buildings and installations;

(*f*) Cost of organization of the enterprise;

(*g*) Engineering and administration costs during construction;

(*h*) Expenses of running-in period;

(*i*) Preparatory installations;

(*j*) Contingencies;

(*k*) Interests during construction.

2. *Estimation of working capital.*

3. *Composition of the investment in national and foreign currency.*

4. *Investment programme.* (In accordance with the working programme examined in chapter IV.)

5. *Annexes.* The detail in the annexes will be similar to that in chapter IV. The following will be itemized, for example: freight costs, insurance, customs and other taxes, unit salaries paid for work similar to that of the enterprise, lists of costs of installation materials, final details of the calculation of working capital, copies of quotations, data on possible price changes, data on exchange rates for imported equipment, etc.

## CHAPTER VI. *BUDGET OF EXPENDITURE AND INCOME BUDGET AND THE ARRANGEMENT OF THE EVALUATION DATA*

1. *Annal costs and income budget at market prices.* Profits and unit production costs for a year's normal production.

2. *Determination of equalization points, with the following factors varying:*

   (*a*) Percentage of production capacity used;
   (*b*) Cost of some important input items;
   (*c*) Selling price of the products.

3. *Grouping and arranging of the data required to prepare the expenditure and income budget:*

   (*a*) Labour budget, on the basis of estimates presented in the engineering chapter, and with estimated unit labour costs;
   (*b*) Budget of miscellaneous material required in the operation and maintenance of the work (sources of supply and prices);
   (*c*) Budget of fuel, power and other materials required for operation and maintenance;
   (*d*) Explanations and details on the cost calculation for depreciation and obsolescence;
   (*e*) Explanations of the way in which distribution costs were obtained;
   (*f*) Other data, depending on the nature of the project and local circumstances.

4. *Other data which may be necessary for the social evaluation of the project:*[5]

   (*a*) Foreign exchange balance of the project in one year's normal operation, relating to the project itself (not including possible indirect effects) and data on possible indirect effects;
   (*b*) Data required to modify market prices which affect the project, in terms of subsidies and taxes;
   (*c*) Data relating to the pricing of the factor at opportunity costs: (i) employ-
   uses of the resources in general; (iv) rates of interest;
   ment situation; (ii) transfers relating to natural resources; (iii) alternative
   (*d*) Significant relationships between the project and other existing enterprises or projects (input-output tables, plans of sources and uses, other relationships);
   (*e*) Enumeration of intangible benefits of the project, and advantages which are difficult to determine.

5. *Annexes.* As in previous chapters, the details of the calculations, the studies and auxiliary calculations, will be inserted in the annexes. In lightly-developed preliminary projects, points 3 and 4, complete, may be attached as annexes.

## CHAPTER VII. *EVALUATION*

There are two main methods of evaluating a project, depending upon whether it is to be from the social or the private entrepreneur's point of view. The private evaluation will be necessary in any case to solve the project's financial

[5] The concepts of social evaluation will be explained in Part Two. The detail will vary in each case, depending upon the nature of the project, the degree of precision required or possible, and the priority criteria which it is desired to apply.

problems; the social evaluation will require varying types of information, according to the criteria to be applied.[6]

1. *Net return on capital invested in the project:*

   (*a*) on the total capital involved in the enterprise;
   (*b*) on the entrepreneur's equity capital.

2. *Value added per unit of capital.*

3. *Rate of turnover of capital.*

4. *Capital intensity.*

5. *Labour employed per unit of capital.*

6. *Marginal social productivity of the capital.*

7. *Labour productivity.*

8. *Benefit-costs ratio.*

9. *Value added per unit of total input.*

10. *Other coefficients.*[7]

11. *Annexes.* Details of the calculations will be given here, and explanations of the special research which might have been necessary in order to compute certain coefficients.

## CHAPTER VIII. *FINANCING AND ORGANIZATION*[8]

1. *Financing:*

   (*a*) Dates on which the capital contributions must be available, according to the investment programme;
   (*b*) Sources of financing; (i) Equity capital; fixed and working capital; (ii) Credits: their sources and conditions and types of credit; form of repayment; type of interest, guarantee, etc.;
   (*c*) Financing in the national currency and in foreign exchange;
   (*d*) Table of sources and uses of funds (Outline of figures relating to the investment programme, sources of financing, income and expenditure budget, amortization of credits, and dividend policy; comparison between the amount involved in servicing credits and the annual cash availabilities to meet it.);
   (*e*) Coefficients reflecting the soundness of the future enterprise's financial structure, or of that which is requesting the credit.

2. *Organization:*

   (*a*) Type of enterprise which it is proposed to create, and the reasons for this decision; general structure of the enterprise;
   (*b*) Legal and institutional problems relating to the execution of the project; patents, permits or other similar items;
   (*c*) Administrative and legal arrangements related to projects in the public sector;
   (*d*) Decision as to whether to construct the work by contract or administration; types of organization recommended, and reasons for these recommendations;
   (*e*) Forecasts for additional studies for: (i) completing the preliminary project

[6] For this reason the plan given here has the same limitations as mentioned in chapter VI, in that the essentials will vary according to the criteria adopted. The points which follow refer to the criteria most often cited in technical literature on priorities, and a warning must be given that the computation of all the coefficients given here is not always justified or possible.

[7] In all the coefficients of social evaluation (2 to 10) the possibility should be admitted of measuring direct and indirect effects, and of pricing the factors at their social cost.

[8] This chapter is unnecessary for the evaluation of the project and establishment of priority, excepting in those cases where there are special problems or conditions similar to those mentioned earlier.

and converting it into a final project; (ii) requests for tenders and awards of contracts for equipment; (iii) requests for bids and awards to contractors;

(*f*) Forecast of the transition period, between the study phase and the execution of the project;

(*g*) Forecast of work related to the project, but which must be carried out by other public or private entities;[9]

(*h*) Forecast regarding the obtaining and training of technical and administrative personnel, both for assembly and for operation of the project;

(*i*) Other forecasts regarding organization, running-in period and operation of the enterprise.

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[9] For example: repair of roads and bridges, assurance of the availability of certain resources, unloading problems in the ports, etc.

Part Two

# EVALUATION

## Chapter I

## PROJECT EVALUATION

### I. Nature of the problem

#### 1. *Objectives, criteria and evaluations coefficients*

The fundamental task of the economist is to contribute directly or indirectly to an allocation of available resources which will enable the maximum advantage to be derived from them. Those who must allot priorities among investment projects face the problem directly and explicitly, and when they recommend that a certain project should be executed, they are in fact confirming that certain resources must be allocated to one specific use in preference to others.

In order to make such a recommendation, the meaning of "advantages" must be defined; there must be some standard or pattern whereby it may be determined that optimum use is being made of the resources. Project evaluation consists precisely in selecting and applying such standards or patterns to the projects being analysed. It would be unnecessary if the projects under study required less than the total available resources. This is an important point, since current practice—especially in the public works sector—is often to prepare only projects for which it is hoped to obtain funds, whereas in fact more should be prepared, so that the evaluation has some practical significance.

Economic evaluation consists of a comparative appreciation between the possible uses of resources represented by the investment projects. The various evaluation criteria, and their greater or lesser complexity, derive in turn from the method of definition of advantages the selection made between the different standards and types of calculation. These criteria are often expressed in terms of numerical coefficients, and in this case they are usually arranged in such a manner that the higher the numerical value, the higher the priority given to them.

#### 2. *Types of priority*

The fixing of priorities involves three types of problems which, although closely related, should be studied separately for practical reasons. The first is the justification of the recommended use of the resources and constitutes the evaluation problem proper. It may be presented in the form of the following question: why produce these goods or services and not others? The second is the justification of the proposed technique, or the problem of technical production alternatives. The question in this case would be—why make the goods or services in this manner? The third problem concerns the date recommended for the actual execution of the project, that is, the allocation of time priority: why do this now and not later?

Apart from this—and whatever the standard of comparison which may be used—projects which involve the completion of work in progress often have priority, since the alternative is that the partial investment will be non-productive.[1]

Consider, for instance, an enterpreneur who has expended a considerable amount of effort in proving the existence of certain mineral deposits and has exhausted his own resources without being able to begin working the deposits in a satisfactory manner. Supposing that, given these circumstances, there is a project to work the mine satisfactorily with additional investments and that new investors are forthcoming. Such a situation could arise, among other reasons, because the mine, which could not be worked commercially in past years, had become a commercial possibility as a result of changes in ore prices.

If the new project is practicable because of earlier investments, then the alternative is clear: either new investments must be made or the previous investment will be lost. If the total investment that the project would require had been foreseen at the outset, it would probably have been discarded, but since it is a case of continuing with a project, the apportionment of funds may be justified in regard to marginal returns.

This occurs when preference is given *a priori* to projects which are half-completed; their marginal return is high, and when confronted with the alternative of completing the project or losing the previous investment, is is usually better to invest more.

#### 3. *Responsibility of the project-maker*

It should be remembered that it is not the project-maker's responsibility to recommend priorities. While each knows his own project, he does not know the others, and therefore cannot make comparisons. Normally, all projects should be evaluated by some central authority which is responsible for programming, according to the criteria which it decides to adopt. There are, nevertheless, two main reasons why the project-maker should remember and understand evaluation problems and techniques. The first concerns the inclusion in the project of the data required for evaluation. Supposing that within an institutional plan there existed a programming body which established priorities after appraising the various projects presented for its consideration, each individual project would have to contain the data required for the calculation of its evaluation coefficient. This implies that the project-maker should understand the most commonly used criteria. Furthermore, if he understands these criteria and the method of computing them, he could simplify the programming body's work by making the evaluation calculations according to the more usual criteria, even though the responsibility for the final comparison must be left to the programming body.

The second reason is intrinsically practical, since it will be unusual to find—at least at present and in the immediate future in Latin America—an ideal institutional plan with such a clear division between the functions of project-makers and those responsible for allocating priorities. Often the same people will fulfil both functions, which means that the project-maker must have adequate knowledge of the problem of priorities.

[1] This statement must be qualified, depending upon the amount already invested and the quality of the initial unfinished project.

### 1. *Measurement*

It will be seen from the above that evaluation consists in measuring objectively certain magnitudes resulting from the project study and in combining them in arithmetical operations in order to obtain the evaluation coefficients. Objectivity does not imply a denial of the existence of different evaluation criteria, nor an argument as to which are more appropriate; once a criterion is defined, however, and its premises accepted as valid, it will be possible to express it in figures. In other words, it will be possible to make a measurement, and although the measurement may be made by different observers, the same result will always be obtained if the principles of the accepted criterion are respected.

Disagreement as to what should be measured and how it should be measured in order to evaluate a project leads in practice to this work being done according to the personal preference of the individuals concerned, to the type of data available and, in general, to the specific conditions of each study.

### 2. *Common aspects of evaluation criteria*

As stated above, the substantive differences between evaluation criteria lie in the various methods of consideration, specification and measurement of what are understood in each case to be the resources employed and the benefits obtained. Whatever these differences may be, any evaluation calculation must tackle the problems conventionally known as pricing, homogeneization and extension. A brief explanation will be given here of these problems in order to simplify the understanding of the general presentation which will be made in this introductory chapter.[2]

#### (a) *Pricing*

The varied physical nature of goods and services means that, for evaluation purposes, their relative volume has to be expressed by means of a common denominator, which is the monetary unit. Pricing threfore consists in assigning prices to goods and services connected with a project, and has decisive importance in evaluation, sice "market prices" are not always representative of the value of goods or services.

Market prices are those normally registered in common transactions in goods or services. To simplify the presentation, market prices corrected for the purpose of evaluating projects will be called social prices or costs.[3]

#### (b) *Homogeneization*

Since evaluation calculations cover the entire useful life of a project, monetary values must be used which will be applicable to transactions at different dates. If such monetary values are to be comparable, they must homogeneized as regards time, by means of calculations of financial equivalences. This is the problem called here the "homogeneization of values".

#### (c) *Extension*

It has already been explained that the execution of a project produces a series of economic chain reactions "backward", or "towards the source", and "forward", or "towards the destination", referring to the source of the input and the destination of goods or services produced. The problem of "extension" involves recognizing and quantifying these economic repercussions of the project within the evaluation criterion adopted.

From this aspect, the evaluation criteria are divided into two main groups: firstly, those which measure effects deriving from the project only, called "direct effects", and, secondly, those which attempt to measure also the indirect effects both as regards resources used and benefits obtained.

The problem of extension is connected with that of pricing. This will become more apparent later when the concept of opportunity cost is discussed. Some authors consider that social pricing and the measurement of indirect effects are conceptually the same thing provided that equilibrium prices are used in pricing.[4]

[2] A more detailed analysis is given below in chapter II.

[3] The criteria used for this correction will be explained below in chapter II.

[4] The authors who share this opinion include Professor Hollis B. Chenery. His views on this subject are set forth at greater length in chapter II, section III, 2, below.

## III. TYPES OF EVALUATION COEFFICIENTS

Since different methods of pricing are available and since the possibility exists of including or omitting the indirect effects and of selecting and defining the standards of comparison in different ways, there are many evaluation criteria and the question arises as to which of them will be the most suitable.

### 1. *Evaluation for the entrepreneur and social evaluation*

Much of the controversy regarding priority criteria undoubtedly arises from the absence of a clear definition of the aims of the evaluation. It has often been forgotten that this depends upon the entity for which the evaluation is being made. Confusion has thus arisen through taking criteria which are adequate from the individual point of view, and attempting to apply them in cases where the selection should be made in the light of social desirability.

Ideas are becoming increasingly clearer regarding the differences between allocating resources according to individual interests and allocating them according to social interests, and regarding the inadequate reflection of consumer preference and the intrinsic value of factors given by market prices. Consequently, there is increasing interest in the changes which must be made in the standards acceptable to a private entrepreneur in order to make them applicable to the social case.

A simple example will indicate the differences between the social and private priority criteria. Supposing that an electricity plant is to be established to meet an unsatisfied demand and that because of the rates in force the net return is not sufficiently attractive to the private entrepreneur. Would the position necessarily be the same from the social point of view? Obviously not. Considering, for instance, the indirect effects of the availability of electric power, the community might be more than amply compensated for the resources employed, even though there were no profits. Thus, while the private entrepreneur would not consider the project practicable, it may have high priority as a social investment.

To mention another case, suppose that in a country where there is some form of import control (for instance, limitations on foreign exchange or import embargoes) an application is presented for the production of a certain type of luxury goods, the importation of which is prohibited. The entrepreneur asks for permission to import the raw material for the industry, justifying this by the argument that it will increase production and provide work for domestic labour. The net return from such an enterprise would probably be extremely high, because of current market prices. A comparison based on the profitability criterion of the private entrepreneur would give this industry the highest priority, but from the point of view of the national interest it might be preferable to use scarce foreign exchange for more important purposes, which could only be appreciated by computing the foreign exchange, not at its market value, but at its estimated intrinsic price, or considering the indirect repercussions of alternative investments, or measuring the value added by the enterprises to the national product.

The above examples demonstrate the great difference between the evaluation criteria: on the one hand, those which may be used for the comparison of private projects; and on the other, those which may be used from the social aspect. What the private entrepreneur regards as benefits, raises no conceptual problems since his prime motive is profit, whether in absolute terms or per unit of capital (net return). Nor are there any doubts as to the form of measurement: in his pricing he is interested only in the market price, and in his extension he is interested only in the direct benefits and costs of the project. In the case of social evaluation,[5] the problem is much more difficult both conceptually and practically.

Finally, it should be mentioned that, regardless of the identity of the promoter or executor of the project or of whether it is in the public or private sector, the financing problem must be solved, which always requires an evaluation in terms of market prices. Again, although priority is determined from the social point of view, many projects are left to private initiative, and in that case it will be necessary to determine if they will be attractive to the private entrepreneur and what incentives might awaken his interest.

For instance, there may be a project which has high potential priority from the social point of view, but which is not attractive in the light of current market prices. If it is desired to have this project carried out there are only two methods: (*a*) the project should be undertaken by the public sector, which would accept any financial risks involved; and (*b*) the Government provides incentives or other measures to improve the market conditions for the project, thereby making it attractive to private capital by means of direct subsidies, tax rebates, etc. If the two methods of evaluation are available, the task of providing the necessary incentives to make specific projects of high social priority equally attractive to the private entrepreneur will be simplified. This presentation provides specific criteria which may be employed in a policy destined to accelerate economic development.

[5] This is explained in point 2 of this section.

### 2. *The various social evaluation criteria*

The greater complexity of social evaluation explains the diversity of the suggested criteria, or of those which could be suggested, and at the same time explains the difficulty of classifying them satisfactorily. In view of this wide range of evaluation standards, two methods of grouping them are given below for the sole purpose of providing a preliminary theoretical outline.

#### (a) *Partial and integral criteria*

The order of priority of projects may be fixed by means of a single coefficient or by a combination of a number of partial coefficients, weighted in some manner. Integral coefficients are those which endeavour to offer a single, total evaluation standard; partial criteria are those which are combined with others.

Integral coefficients involve both theoretical and calculation complications, which require a longer explanation than can be given here and which will be dealt with individually in the appropriate chapter. Partial criteria cover limited economic aspects, and the resulting coefficients therefore qualify the project from these aspects only. In order to establish a general qualification, the partial coefficients must be combined in some way, either by weighting them or not depending upon the criterion being used. Amongst these partial evaluation criteria mention might be made of labour employed per unit of capital and the net contribution to the balance of payments per unit of total investment or of the foreign exchange component of the investment.

#### (b) *The productivity of a single resource or of the complex of input factors*

Evaluation coefficients may be defined arithmetically as the ratios between what in general terms may be called the "advantages" and "disadvantages" of the project. If the advantages are the numerator and the disadvantages the denominator, it will be possible to classify the coefficients according to what they maximize (advantages) and minimize (disadvantages).

Evaluation formulae measure some types of productivity and a distinction may be made between those criteria which measure the productivity of one single factor or economic resource (for example, capital or labour) and those which measure the productivity of the whole of the input factors.[6]

Once it is determined what productivity the evaluation criterion should express—that is to say, what is the denominator of the fraction—a considerable range of possible values still remains to be placed in the numerator. Thus, if it is desired to measure the productivity of capital, it may be done in terms of value added per unit of capital, of foreign exchange savings per unit of capital, of persons employed per unit of capital, etc. A similar procedure may be applied to measure the productivity of the other single factors or of the complex of inputs. These coefficients may

[6] The term productivity is used in the sense of volume of production (or other benefit, such as foreign exchange savings) obtained per unit or complex of resources employed. This interpretation must not be confused with the theoretical concept of productivity, which is the volume of production attributable to each unit of the factor, i.e., the contribution of that factor to production.

be total or partial; they may include or omit indirect repercussions, and may or may not use market prices for pricing. This explains the enormous range of possible combinations for evaluation and the theoretical and practical problems which it involves.

From the linear programming approach, any of the coefficients that measure the productivity of a factor or factors may be used indiscriminately as a priority criterion, provided that the equilibrium prices that would prevail once the programme had been carried out were used in the calculations in relation both to inputs and to production estimated according to the project.[7]

[7] See chapter II, section II, 3 (d) below.

(c) *Evaluation for each governmental unit participating in a project.*

It may often happen that more than one public agency will participate in the financing and/or administration of a project. In such cases, it is useful to make a separate estimate of costs and benefits for each agency, i.e. of the way in which total costs and benefits will be distributed between them.[8]

[8] The methods of presentation of such calculation are explained in greater detail in *Formulation and economic appraisal of development projects,* United Nations publication, Sales No.: 1951.II.G.4, vol. I.

## IV. Choice of evaluation criteria

### 1. *Some basic concepts*

From the point of view of the project-maker, it is advisable to distinguish between the theoretical and practical aspects involved in the selection of the most suitable evaluation criteria. The theoretical treatment of the problem of project evaluation leads to considerations outside the scope of this *Manual.* It is a fundamental subject for programmers of economic development and is at present receiving considerable attention, since it is related to the basic theoretical problem of allocating resources. It has already been stressed that this *Manual* does not claim to make any new theoretical contributions, but only to present the problem and to make known some of the solutions offered, so as to give the project-maker guidance concerning the data which must be included in the study in order to simplify evaluation. This is the practical aspect of the problem, to which the closest attention has been paid.

For the above reasons, only a brief theoretical outline will be given of what economic development seeks to maximize and minimize, and of the concepts of productivity and evaluation.

In general terms it may be said that, in the case of social evaluation, the main item of interest is the increase of the national product which may be obtained per unit of the complex of resources employed in the project. Social prices should be used for all the magnitudes and not just the benefits and resources directly related to the project but also the so-called indirect benefits and costs must be taken into account.

In many cases, however, it is better to measure the productivity of the scarce resources, using capital, labour or foreign exchange as the denominator in the evaluation ratio. The argument then is that, if certain resources are scarce, the national product which can be obtained per unit of the scarce resources must be the maximum.

Owing to the variety of the resources which prevents arithmetical additions and which makes it necessary to solve the pricing problem, productivity is often measured by the relation between the product obtained using all the factors and the units employed of each, preferably singling out the labour factor, with which the term productivity is often associated. But such measuring may lead to an incomplete evaluation, since the productive process involves the joint employment of all the factors which are added to, and become part of, the so-called "formula" or "function" of production.[9]

[9] This being so, there is the possibility of basing the presentation on linear programming and equilibrium prices which will be explained later.

### 2. *Partial and aggregate productivity*

The problem may be appreciated clearly when, for instance, it involves the measurement of possible increases in labour productivity, which may be due either to a genuine increase in labour efficiency or to replacement by another factor. Agricultural production may be increased because the workers make better use of their time, because they get better seed, tractors or other machines. If the additional data are omitted and only production per man is measured, it will not be possible to establish whether there has been a greater output with the same sum of factors, one of which gave better results, or if it was due to an increase in the resources employed.

According to the above, if the comparison of two projects $A$ and $B$ is based on the productivity of a single factor $X$, considered as the key item, it will never be known precisely whether $A$ is better than $B$ because the factor $X$ gives better results in $A$ than in $B$ or because in $A$ it is accompanied by more or better additional resources.

It therefore follows that in evaluation it will be im-

**Table XII**

CAPITAL AND PRODUCTION IN COTTON WEAVING MILLS IN INDIA

| | *Capital per worker (A)* (Rupees) | *Production per worker (B)* (Rupees) | *Capital per unit of production (ratio A/B)* | *Index of workers employed per unit of capital*[a] | *Index of production per worker*[a] |
|---|---|---|---|---|---|
| Large modern factory | 1 200 | 650 | 1.9 | 100 | 1 440 |
| Small-scale mechanical weaving. . . . . . | 300 | 200 | 1.5 | 400 | 440 |
| Automatic weaving in cottage industry . . | 90 | 80 | 1.1 | 1 300 | 180 |
| Hand weaving in Cottage industry. . . | 35 | 45 | 0.8 | 3 400 | 100 |

*Source*: P. S. Lokanathan, "Cottage Industries and the Plan", *Eastern Economists,* 23 July 1943. Quoted by Horace Belshaw in *Population Growth and Levels of Consumption,* George Allen and Unwin Ltd., London.
*Note*: The last two columns do not appear in the original table.
[a] Rounded figures.

portant to measure the productivity of the complex of resources used according to the production formula of each project, in spite of the pricing problems mentioned earlier.[10] The knowledge of individual productivities will also be useful, since it will show the composition of the production formula, indicating the relative participation of the various input items in the common product.

The notable substitution possibilities which may be achieved in some cases between the labour and capital factors may be seen from table XII, which shows the relations between capital, production and employment in Indian cotton weaving mills.

These data show that production per worker rises from 45 to 650 supees, i.e., more than 14 times, when hand weaving in cottage industry is replaced by a modern large-scale factory. To make this possible, the capital per worker must be increased from 35 to 1,200 rupees, or 34 times. Thus, to attain this productivity per worker, the capital per unit of production must be more than doubled (from 0.8 to 1.9).

This example shows that a comparison based only on productivity per man, disregarding simultaneous demands on capital, would only present a limited aspect of the problem and might result in projects receiving priority which they would not have if the other resources were taken into account. Further mention will be made of this subject when labour productivity as an evaluation coefficient is discussed.

[10] These problems become more acute under inflationary conditions, which distort the whole price system.

### 3. *Definition of benefits*

The above analysis has only discussed the method of considering the factors involved in production, that is, the denominator of the evaluation coefficient. A similar presentation may be made of the benefits or effects of the project quantified in the numerator of the ratio, since projects produce both direct and indirect effects which may be measured in terms of the aggregate value of production, value added to the production, balance of payments, employment, profits, or other forms. This means that there are practical and conceptual limitations to the combination of these effects and to their addition as homogeneous units. At times, partial coefficients are therefore proposed for measuring the separate effect of each. On the basis of these, a general idea could be obtained which would make it possible to determine priorities, greater weight being given to the factor which is considered to be most important in each case.

It may be mentioned that this weighting may achieve a degree of subjectivity similar to that of the appreciations required for overcoming the practical limitations to obtaining the data needed for integral evaluation.

Having examined the theoretical arguments regarding evaluation—although only a few have been mentioned, and those only very generally—it will be sufficient to explain here only the better-known criteria and the method of calculating their respective coefficients. It should be kept in mind that it is not the project-maker's responsibility to establish priorities, but only to provide the data for the calculation of the coefficients.

## V. Political and economic factors in evaluation

Political considerations often have a decisive effect on investment priorities. Furthermore, there are many projects for the supply of services which are not marketable, and for which the demand is not expressed in monetary terms but only in petitions or efforts of interested groups directed through municipal or parliamentary channels. Typical examples are sewerage, street lighting or paving. In many of these projects it is difficult to express the benefits in terms of money, although the exact costs may be known. Decisions of this kind are also often affected by politico-social factors.

The political factors which often affect the order of priority of projects may conveniently be grouped into two categories. One is related to military strategy. There are railways, roads and bridges which follow their present route solely for reasons of military strategy. There are also industries—the synthetic nitrogen industry in Germany for example—which owe their existence to military considerations, just as others are not established in certain areas for the same reasons.

Another factor to be remembered is short-term political strategy, which affects investment policy. This strategy is an outcome of the requests, impulses and inhibitions which Governments must reconcile, direct and harmonize within the general standards of the economic policy adopted. A realistic appreciation of national problems cannot disregard these circumstantial political influences.

Similarly, it must be remembered that investment priorities may be affected by the necessity for greater administrative and social cohesion of the country.

The foregoing shows that economic evaluation criteria are not so important after all. It may be argued that, if the economic evaluation is subordinated to a political criterion in the end, there will be no justification for a careful evaluation. Any discussion or priorities would be purely academic and would not be based on a realistic point of view. The reverse, however, is the truth. If project *A* is preferable to project *B* for political reasons, whereas the economic evaluation shows the opposite to be the case, the price to be paid for this political decision must be known. This price may or may not be reasonable, and to ascertain it is the gist of the problem of the political decision, but this knowledge can only come from a calculation of the economic priority coefficients. The project may at times present the national Government with a dual evaluation problem: that of economic evaluation and of the State's motives. In order to take a decision, the governing body must clearly understand the cost of the alternatives and only it can make a true comparison.

At the same time, the extreme view must not be taken that all projects are subject to a specifically political analysis. Within a certain margin of economic policy and institutional reality, it is most probable that the decision on the majority of projects is taken simply on the basis of an economic evaluation criterion. In many cases, political influence may be limited to the preference of one economic criterion over another. This leaves no doubt about the importance of economic evaluation.

## Chapter II

# FINANCIAL EQUIVALENCES, PRICING AND INDIRECT EFFECTS

## I. Financial equivalences[1]

### 1. *General considerations*

Evaluation calculations must take the time factor into account in the use of capital, in the availability of income and in the scheduling of expenditure, and this involves the adoption of an interest rate. The problem consists in the homogeneization of monetary series in terms of time, since for the purposes of economic comparison and evaluation, income and expenditures at different times cannot be considered homogeneous. The evaluation calculations will not only refer to the results of a given year, but to all costs and income throughout the life of the enterprise. The sum of such costs and income cannot be calculated unless the components are homogeneized and expressed in equivalent terms in relation to time. The same reasoning is followed when the annual values of income or expenditure are not equal. It may happen that, during the project's useful life, the enterprise operates with different capacities, or that the pricing of various factors fluctuates because of changes in prices, exchange rates, or for other reasons. It these figures are to be reduced to uniform and equivalent annual values, calculations must be made to regularize them in terms of time, so that they can be homogeneized and standardized annually.

The most commonly used equivalence methods are those of equivalent annual standard value and of present worth. Since both are derived from the same formulae, neither has a greater intrinsic value than the other. The application of either method will depend upon the calculation facilities or data available or the aims pursued. This will be seen more clearly as the explanation proceeds and as the various methods of deducing the formulae are analysed.

### 2. *Annual equivalent standard cost*

#### (a) *Bases*

The total costs of a project consist of an initial outlay, i.e., the investment on a given date, and a further series of annual outlays throughout the project's useful life. The method of uniform annual equivalent standard cost enables a sum invested on a given date to be converted into an equivalent series of equal annual values.

[1] An explanation of this subject is given here from the point of view of the calculations necessary for project evaluation. For a more detailed study reference may be made, for instance, to Eugene L. Grant, *Principles of Engineering Economy*, The Ronald Press Company, New York, 1950. See also Clarence E. Bullinger, *Engineering Economic Analysis*, McGraw-Hill Book Company, New York, 1950. (There is a Spanish translation: *Análises económicos para ingenieros*, Madrid, Aguilar, 1953.)

In annex I of this chapter, certain deductions from equivalence formulae are given, which are not often found in the specialized literature and which may serve to give a better understanding. It is not essential to read them in order to understand what follows, but it would be useful in specific cases of evaluation calculations.

If the number of years or periods of the project's useful life, the rate of interest and the volume of the investment are known, the investment can be converted into a series of equivalent annual payments, which may be added to the remaining annal disbursements in order to obtain a total annual cost of the project.

The outlay involved in the original investment may be considered as an advance payment for a specific input which is made up by the assets that may be produced. This will in fact be used up gradually throughout the project's useful life but only one payment is made, at the beginning, and constitutes the initial investment subject to depreciation. In order to add the cost of this particular input to the remainder, which are paid as they are used, the initial investment is converted into a series of equal annual quotas, which are of the same type as the rest and can therefore be added together. For this purpose, the following formula is used:

$$(1) \quad R = P \left[ \frac{i(1+i)^n}{(1+i)^n - 1} \right] = P \text{ (c.r.f.)}$$

The initial investment may be converted into a series of equal annual payments $R$, with $n$ as the period of recovery, and $i$ the rate of interest.[2] Using this formula, depreciation and interest, or the payment of amortization and interest on a credit can be considered as a single annual item. The factor in brackets (c.r.f.) is known as the "capital recovery factor" and, as may be seen from the formula, it also includes interest. If the rate of interest and the term of the investment are known, the recovery factor may be obtained from financial tables.[3]

#### (b) *Calculation of the equivalent annual cost*

*Example 1.* Suppose that two projects A and B are being considered, with characteristics as shown in table XIII.

[2] The rate $i$ is expressed in relation to unity and not as a percentage. If the rate is 6 per cent, $i$ will be 0.06.

[3] See the deduction of this formula in the annex to his chapter.

**Table XIII**

EXAMPLE 1. TECHNICAL ALTERNATIVES FOR THE SAME PRODUCTION

*(Monetary units)*

| | *A* | *B* |
|---|---|---|
| Fixed investment | 10 000 | 7 000 |
| Production costs (operation, maintenance, taxes, interests and rents, etc.) | 3 000 | 3 500 |
| Duration (years) | 10 | 10 |
| Rate of interest (percentage) | 6 | 6 |

In order to know the project's total cost, expressed in equivalent annual cost, the fixed investment is converted into an equivalent annual cost by means of the formula given above. The capital recovery factor (c.r.f.) for 10 years at 6 per cent is, according to the tables, 0.13587, so that the equivalent annual cost of the fixed investment is:

$$\text{Project A:} \quad 10\,000 \times 0.13587 = 1\,359$$
$$\text{Project B:} \quad 7\,000 \times 0.13587 = 951$$

The total annual cost is the sum of the annual production costs and the equivalent costs of the investment, or:

$$\text{Project A:} = 1\,359 + 3\,000 = 4\,359$$
$$\text{Project B:} = 951 + 3\,500 = 4\,451$$

If both projects produce the same quality and quantity of goods—that is to say, the same economic value—project B is the more expensive. If this type of calculation is omitted, and the interest rate is considered to be zero, the equivalent annual cost of the investment will simply be 1 000 in the case of A and 700 in that of B, i.e., the total investment divided by the number of years.

The annual costs calculated in this manner will be:

$$\text{Project A:} = 1\,000 + 3\,000 = 4\,000$$
$$\text{Project B:} = 700 + 3\,500 = 4\,200$$

### (c) *Effect of the interest rate*

It is interesting to see what happens when there are large variations in the interest rate. The results in terms of equivalent annual cost with rates of 2 and 10 per cent are shown in table XIV.

Table XV summarized the comparison and shows that project A's advantage over project B decreases as the rate of interest rises. The advantage is due to the fact that project A has a lower annual production cost because of the greater capital intensity, but it gradually disappears as the use of this capital becomes more expensive, until the moment arrives when the cost of capital is so high that it no longer compensates for the lower operating costs.

If technical alternatives such as those shown in the example are compared with the possibility of obtaining a credit, the interest rate may be very important in deciding the structure of the fixed investment in the project.[4]

[4] See the comments on equity capital and long-term credits in Part One, chapter VII, section II, 3.

**Table XIV**

EXAMPLE 1. COMPARISON OF DIFFERENT TECHNICAL ALTERNATIVES AT DIFFERENT INTEREST RATES

*(Percentages)*

| | *A* | | *B* | |
|---|---|---|---|---|
| | 2 | 10 | 2 | 10 |
| Capital recovery factor | 0.11133 | 0.16275 | 0.11133 | 0.16275 |
| Equivalent annual cost of the investment | 1 113 | 1 627 | 779 | 1 138 |
| Annual production cost | 3 000 | 3 000 | 3 500 | 3 500 |
| Total annual cost | 4 113 | 4 627 | 4 279 | 4 638 |

**Table XV**

EXAMPLE 1. TOTAL EQUIVALENT ANNUAL COSTS

*(Monetary units)*

| *Rate of interest (Percentages)* | *A* | *B* | *B—A* |
|---|---|---|---|
| 0 | 4 000 | 4 200 | 200 |
| 2 | 4 113 | 4 279 | 166 |
| 6 | 4 359 | 4 451 | 92 |
| 10 | 4 627 | 4 638 | 11 |

### (d) *Residual value of the fixed investment*

When part of the fixed investment is recovered at the end of the project's useful life the formula for equivalent annual cost is:

$$R = (P - L) \times (\text{c.r.f.}) + Li$$

where $L$ is the part recovered.

The (*c.r.f.*) already known is multiplied by $(P - L)$, that is, the difference between the initial investment and the amount recovered at the end of the project's life. Obviously, $L$ must be subtracted, since it does not enter into the production. But it is recovered *at the end,* and during all the $n$ years of the project's life it has been producing goods, services, or both. The use of this capital $L$ requires the payment of interest $i$, and the annual value of this interest is $Li$. Therefore to the equivalent annual cost of the recoverable investment $(P - L)$ must be added $Li$, which is the annual cost of using the capital corresponding to that part of the investment which is recovered as residual value.

### (e) *Formulae for the approximate method*

The equivalent annual cost is often expressed in terms of linear depreciation, the investment being simply divided by the number of years. This is equivalent to repaying a credit by annual amortization quotas; the interest on this credit is paid on the balance owed. The annual quotas are not equal, since the amount of interest is reduced in arithmetical progression. Nevertheless, as an approximate formula for calculating the equivalent annual cost, the simple arithmetical average of the series of payments is often used. The point may be illustrated by an example.

*Example 2.* Suppose that it is desired to pay (or recover) an investment of 10 000 at 6 per cent interest in 5 years, amortizing equal quotas of 2 000 annually and paying each year the interest on the balance. (See table XVI, in which the date of the investment is the year $O$ and the time is measured in years as from that date).

The value 2 360 is approximately the equivalent annual cost of the investment, that is, the sum of the annual quota of 2 000 and the average of the annual interest. In fact, this is not the annual equivalent standard cost, since it is assumed that the simple arithmetical average gives a figure which adequately includes compound interest; the equivalent annual cost calculated by the accurate method is 2 374. The difference is undoubtedly slight compared to the degree of general precision usually achieved in the study, so that arithmetical average values are often used, always assuming that the project is not of long duration nor the interest rate very high. In the case of long periods, the cumulative effect adds considerably to the difference.

Table XVI

EXAMPLE 2. RECOVERY OF A CAPITAL OF 10 000 IN 5 YEARS AT 6 PER CENT, AMORTIZING EQUAL ANNUAL QUOTAS

*(Monetary units)*

| End of year | Annual interest (for balances at the beginning of the year) | Total owed before end-of-year payment | End-of-year payment | Balance owed after end of year |
|---|---|---|---|---|
| 0 ...... | — | — | — | 10 000 |
| 1 ...... | 600 | 10 600 | 2 600 | 8 000 |
| 2 ...... | 480 | 8 480 | 2 480 | 6 000 |
| 3 ...... | 360 | 6 360 | 2 360 | 4 000 |
| 4 ...... | 240 | 4 240 | 2 240 | 2 000 |
| 5 ...... | 120 | 2 120 | 2 120 | — |
| Total ..... | *1 800* | | *11 800* | |
| Average ... | 360 | | 2 360 | |

The formula which gives the average interest is obtained as the average of an arithmetical progression whose first component is *Pi* (in the case of the example, the interest for the first year: $600 = 0.06 \times 10\,000$) and whose final component is $\frac{Pi}{n}$ (in the case of the example, the interest for the final year $120 = 0.06 \times 2\,000$, this latter figure being the total amount of the investment divided by the number of years for recovery). The formula which gives the average interest is:

$$\frac{Pi}{2} \times \frac{(n + 1)}{n}$$

If the linear depreciation $\left(\frac{P}{n}\right)$ is added to this formula, the result will be the equivalent annual cost.

$$(2) \quad \frac{P}{n} + i\frac{(n + 1)}{2n} = P\left[\frac{1}{n} + i\frac{(n + 1)}{2n}\right]$$

$$= P \ (c.r.f.)$$

It may be seen that structure of formula (2) is similar to that of formula (1); the difference is in the algebraic expressions which measure (*c.r.f.*) in the two cases.

## (f) *Comparison of methods*

Table XVII shows how the difference between the methods widens as the interest rate or the period increases.

When the fixed investment has a residual value, the approximate formula method is the same as that already seen for the accurate method, except that (*c.r.f.*) is calculated on the basis of average interest.

## (g) *Errors in simplifying the calculations*

Errors are very often made when the depreciation is calculated in linear terms, and annual interest is also charged on the total investment. This method is inaccurate, and exaggerates costs, since the initial investment becomes smaller each year in proportion to the depreciation, and it is illogical to suppose that interest will be paid on all the initial capital during the whole period. To make the calculation in this manner is the same as calculating an equivalent annual cost at a much higher interest rate than that explicitly assumed.

In the majority of cases, to convert the initial investment into an equivalent annual cost, it is sufficient to use the approximate formula (linear depreciation plus average interest), but it is not correct to assume that the equivalent annual cost will be the linear depreciation plus interest for the *whole* of the initial capital.

Table XVII

RECOVERY FACTORS USING ACCURATE AND APPROXIMATE METHODS

| *Recovery period (in years)* | *Accurate method (formula 1)* | *Approximate method (formula 2)* | *Percentage error* |
|---|---|---|---|
| | *(c.r.f) at 4 per cent interest* | | |
| 5 ...... | 0.22463 | 0.22400 | — 0.3 |
| 10 ...... | 0.12329 | 0.12200 | — 1.0 |
| 15 ...... | 0.08994 | 0.8800 | — 2.0 |
| 20 ...... | 0.07358 | 0.071100 | — 4.0 |
| 50 ...... | 0.04655 | 0.04040 | — 13.0 |
| 100 ...... | 0.04081 | 0.03020 | — 26.0 |
| | *(c.r.f) at 8 per cent interest* | | |
| 5 ...... | 0.25046 | 0.24800 | — 2.0 |
| 10 ...... | 0.14903 | 0.14400 | — 6.0 |
| 15 ...... | 0.11683 | 0.10933 | — 11.0 |
| 20 ...... | 0.10185 | 0.09200 | — 16.0 |
| 50 ...... | 0.08174 | 0.06080 | — 33.0 |
| 100 ...... | 0.08004 | 0.05040 | — 41.0 |

# 3. *Present worth*

## (a) *Concept of present worth*

Instead of expressing all the values in terms of annual outlay, they may be expressed in terms of the initial investment, reducing all annual payments to the equivalent of only one, made at the time of the investment. In this case, the formulae "discount" future values, allowing the investment costs to be added to all the annual costs. Given a series of periodical values *n* and an interest rate *i*, the formulae will enable the equivalent initial investment to be calculated. The conversion to present worth is often made at the initial date, but the same formulae make conversion possible at any desired date. Naturally, this process is also applied to income.

The same formula 1 is used here, removing the initial value.

$$P = R\,\frac{1}{(c.r.f.)} = R \ (p.w.f.)$$

The reciprocal value of the capital recovery factor (*c.r.f.*) is known as the "present worth factor" (*p.w.f.*), and its value is also found in financial tables.

## (b) *Calculation of present worth*

*Example 3.* Suppose that it is desired to calculate the present worth of the figures for annual costs and income in projects A and B of example 1.

The basic data are as set forth in table XIII.

The present worth factor of the series for 10 years at 6 per cent interest is 7.36, which means that to obtain the present worth of the costs, they must be multiplied by 7.36. Once this has been done, the present worth of the costs will be 22 080 for project A and 25 760 for project B.

The total costs at present worth of project A and B are given in table XVIII.

The above numerical calculation shows again that the reduction to equivalent cost and present worth are calculations which conform to the same concept and follow the same arithmetical operations, since values for items III and V are practically the same. (The differences are due to rounding-off.)

### 4. *Some special cases in calculating equivalences*

The above formulae are simple to apply when the two alternatives under comparison have the same useful life and the annual series are uniform. The problem may arise, however, of comparison of cases where the annual values or the periods of useful life differ.

#### (a) *Projects with different useful lives*

Assume the possibility of producing annually the same quantity and quality of goods and services, but with projects which have different useful lives; there is no reason why the comparison of the alternatives should not be made by means of a calculation of the equivalent annual cost, since the annual production will be the same for both alternatives.

In these cases, it will also be as well to take into account the possibilities of technical innovations in the alternatives being compared. For example, when comparing two projects A and B which produce the same annual value at the same total annual cost, the project with the shorter duration would be preferable, because of possible technical innovations which would allow cheaper production or other advantages in the future; the enterprise which chooses the shorter duration could benefit earlier from such innovations.

#### (b) *The case of unequal annual expenditure or income*

If a project's annual operating expenses are unequal, little will be gained by expressing the initial investment as an equivalent annual cost, since it will not be known which year should be taken as representative. In these cases, the comparison of the projects can best be made by means of a calculation of present worth. Present worth may be converted into annual equivalent standard cost for any desired number of years, so that the comparison will also be possible in terms of annual cost. This type of calculation is illustrated by the following example.

*Example 4.* An evaluation is to be made of a manufacturing project, whose characteristics in an unspecified monetary unit (m.u.) are as follows:

*Fixed investment* (including interest during construction, that is, present worth at the time of entry into operation): 16 millions m.u.

*Useful life:* 15 years.

*Physical production capacity:* 1 million units per year.

*Anticipated capacity utilization:* 50 per cent per year in the first 3 years, 75 per cent per year in the second 2 years, and 100 per cent per year in the final 10 years.

*Estimated unit production costs at current prices:* With the factory working at 50 per cent capacity, 14 m.u. each; at 75 per cent capacity, 12 m.u. each; at 100 per cent capacity, 10 m.u. each. Price variations are expected in the course of time, and in the eleventh to fifteenth year the unit cost will fall to 9 m.u. These costs do not include depreciation or taxes, but do include interest on working capital, which is assumed to be obtained by means of short-terms loans.

*Selling prices of the product:* 14 m.u. each, except in the eleventh to fifteenth year, when it will decrease to 12 m.u. each.

On the basis of the above data and at 6, 8 and 10 per cent interest, it is proposed to calculate the present worth of all costs and income at the date of the investment and to express these values in terms of equivalent annual cost.

Table XIX summarizes the balance of income and expenditure of the project.

Since the annual income and expenditure vary, the values must be shown as present worth at the initial date in order to obtain an equivalent annual value. Once the calculation of present worth has been made, it will be possible, if so desired, to convert these amounts into annual equivalent standard values. A detailed explanation follows of the procedure for calculating present worth of income and expenditure at 6 per cent interest.

*Years 1 to 3.* The present worth factor for 3 years at 6 per cent interest will be 2.673. The present worth of income and expenditure is therefore:

$$\text{Income: } 7 \times 2.673 = 18.711 \text{ million}$$
$$\text{Expenditure: } 7 \times 2.673 = 18.711 \text{ million}$$

(present worth of a series of 3 equal years).

**Table XVIII**

EXAMPLE 3. CALCULATION OF PRESENT WORTH OF COSTS IN PROJECTS A AND B

*(Monetary units)*

| | *Project A* | *Project B* |
|---|---|---|
| I. Fixed investment | 10 000 | 7 000 |
| II. Present worth of annual costs | 22 080 | 25 760 |
| III. Total present worth of costs | 32 080 | 32 760 |
| IV. Equivalent annual cost of III, according to use of (c.r.f.) at 6 per cent and 10 years | 4 359 | 4 451 |
| V. Present worth of the equivalent annual cost (product of IV and the present worth factor 7.36) | 32 082 | 32 759 |

**Table XIX**

EXAMPLE 4. INCOME AND EXPENDITURE OF THE PROJECT DURING 15 YEARS OF USEFUL LIFE

*(Monetary units)*

| *Years* | *Annual production (millions of units)* | *Unit cost*[a] | *Expenditure (total direct cost in millions)* | *Unit selling price*[a] | *Income (millions)* | *Income minus expenditure (net income in millions)* |
|---|---|---|---|---|---|---|
| 1 to 3 | 0.50 | 14 | 7.0 | 14 | 7.0 | 0.0 |
| 4 and 5 | 0.75 | 12 | 9.0 | 14 | 10.5 | 1.5 |
| 6 to 10 | 1.00 | 10 | 10.0 | 14 | 14.0 | 4.0 |
| 11 to 15 | 1.00 | 9 | 9.0 | 12 | 12.0 | 3.0 |

[a] Cost and price expressed in terms of monetary units.

**Table XX**

EXAMPLE 4. CALCULATION OF PRESENT WORTH OF ANNUAL VALUES

*(Millions of monetary units)*

| | *Singular present worth factor* | *Annual income* | *Present worth of income at year O* | *Annual expenditure* | *Present worth of expenditure at year O* |
|---|---|---|---|---|---|
| Year 4 | 0.7921 | 10.5 | 8.317 | 9.0 | 7.129 |
| Year 5 | 0.7473 | 10.5 | 7.847 | 9.0 | 6.726 |
| *Total* | | | *16.164* | | *13.855* |

*Years 4 and 5.* Since present worth is to be calculated for the year 0, that is, the date of entry into operation, each year will be calculated separately. For 4 years at 6 per cent, the singular present worth factor is 0.7921, and for 5 years 0.7473. The present worth of income and expenditure for years 4 and 5 may be seen from table XX.

Note the different procedure in the two cases. In the first, the present worth of a uniform series of 3 equal years was calculated (7 million for each year, for both income and expenditure). The present worth factor of the series was then applied. In the second case, the same formula cannot be used, since the present worth is required, not for the date when the series commenced (years 4 and 5 with equal annual values) but for the same initial date as for the first case, which was earlier. For this reason, each year is calculated separately, applying the *singular* present worth factor. The calculation may be simplified by applying the factor for the series to years 4 and 5, and then the singular factor to the one resulting from the previous operation, as shown for the following period.

*Years 6 to 10.* This is a series of 5 years of equal income and expenditure values. First, the present worth of the 5 years is calculated, using the present worth formula for the series. The factor is 4 212, so that the present worth of income in year 5 will be $14 \times 4\,212 = 58.97$ million and the expenditure $10 \times 4\,212 = 42.12$ million. The present worth of these values must now be calculated for the year 0, using the singular present worth factor, which is 0.7473 at 5 years and 6 per cent. The present worth of total income in year 0 is therefore 44 070 million, and expenditure 31 478 million.

*Years 11 to 15.* The present worth in year 0 is calculated in a similar manner to be 28 228 million for income, and 21 170 for expenditure.

The total present worth at 6 per cent is shown in table XXI.

A similar procedure may be followed for the interest rates of 8 and 10 per cent, giving the final present worth values of income and expenditure as shown in table XXII.

**Table XXI**

EXAMPLE 4. TOTAL PRESENT WORTH AT 6 PER CENT

*(Millions of monetary units)*

| *Years* | *Income* | *Expenditure* |
|---|---|---|
| 1 to 3 . . . . . . | 18.711 | 18.711 |
| 4 and 5 . . . . | 16.164 | 13.855 |
| 6 to 10. . . . . | 44.070 | 31.478 |
| 11 to 15. . . . . | 28.228 | 21.170 |
| *Total* . . . . . | *107.173* | *85.214* |

The total present worth of costs is obtained by adding the value of the fixed investment to the present worth of total expenditure (see table XXII).

The present worth of total income has been added to table XXIII, and item V shows the ratio between present worth of income and costs, which is one of the evaluation coefficients explained later.

If the present worth is known, the values can be converted into annual equivalent standard values, using the capital recovery factor (*c.r.f.*). Table XXIV shows these conversions at different interest rates.

**Table XXII**

EXAMPLE 4. TOTAL PRESENT WORTH AT DIFFERENT INTEREST RATES

*(Millions of monetary units)*

| *Percentage* | *Income* | *Expenditure* |
|---|---|---|
| 10 . . . . . . . . . | 107.18 | 85.21 |
| 8 . . . . . . . . . | 93.14 | 74.61 |
| 6 . . . . . . . . . | 81.59 | 65.85 |

**Table XXIII**

EXAMPLE 4. TOTAL COSTS AT DIFFERENT INTEREST RATES

*(Millions of monetary units)*

| | *Percentage* 6 | 8 | 10 |
|---|---|---|---|
| I. Present worth of total expenditure[a]. . . . . . . . . . . . . | 85.21 | 74.61 | 65.85 |
| II. Investment. . . . . . . . . . | 16.00 | 16.00 | 16.00 |
| III. Present worth of total costs . | 101.21 | 90.61 | 81.85 |
| IV. Present worth of total income[a]. | 107.18 | 93.14 | 81.59 |
| V. Present worth of income-costs ratio (IV/III) . . . . . . . . | 1.06 | 1.02 | 0.99 |

[a] Table XXII.

**Table XXIV**

EXAMPLE 4. CONVERSION OF PRESENT WORTH VALUES INTO UNIFORM EQUIVALENT ANNUAL VALUES, WITH DIFFERENT INTEREST RATES

*(Millions of monetary units)*

| *Interest rate (Percentage)* | *Factor (c.r.f.) at 15 years* | *Present worth of costs*[a] | *Equivalent annual costs* | *Present worth of income*[b] | *Equivalent annual income* |
|---|---|---|---|---|---|
| 6 | 0.10296 | 101.2 | 10.42 | 107.2 | 11.0 |
| 8 | 0.11683 | 90.6 | 10.58 | 93.1 | 10.88 |
| 10 | 0.13147 | 81.9 | 10.77 | 81.6 | 10.73 |

[a] Table XXIII.
[b] Table XXII.

### 1. *Market prices and social cost*

The market price would represent the true value of goods and services if the law of supply and demand operated freely, under perfect competitive conditions, with full employment of all resources and complete mobility of all factors. If, because of any interference, obstacles or regulations, these conditions do not exist, then the price system will be distorted; it will not correspond to that ideal system of equilibrium nor represent the value of the factors from the point of view of the community as a whole. It is therefore considered necessary to correct market prices, in order to obtain what has been termed the "social cost" of the factors.

At the same time specific pricing problems cannot be disregarded in a project study. A few simple questions will helps to clarify this point in the case of machinery for a project in the public sector: Should customs duties be included in the cost or not? Should the cost be calculated of goods imported at what is known to be a preferential exchange rate? The rational answers to such questions raise pricing problems.

The approach to the subject here will be practical rather than theoretical. An attempt will be made to offer useful suggestions for the preparation and evaluation of a project, and to review only those fundamental theoretical premises which are implicit in the criteria. The purpose is to provide criteria and working tools rather than ready-made formulae and solutions. Experience, theoretical knowledge and common sense will always be the deciding factors.

The proposed basic price modifications may be divided into two broad groups, which are not mutually exclusive. Some consist in eliminating the effects of taxes or subsidies from the prices, while others use so-called "opportunity costs". The opportunity cost of a resource required for a project is that value—chargeable to this resource—which is no longer produced in some other activity in which it could be used, and from which it is diverted by its employment in the project.[5]

### 2. *Elimination of taxes and subsidies*

#### (a) *Obvious cases*

The object of eliminating the influence on prices of taxes and subsidies is to obtain the value of the goods and services at the true cost of the factors. For instance, greater or lesser customs duties or sales taxes cause variations in selling prices, unrelated to the productive effort involved.[6]

Correction is simple when it is limited to the direct effects of these taxes. If, for instance, there is a sales tax of X monetary units per unit sold, it is easy to subtract this from the market price, and the difference is the monetary value of that unit. It is also simple to eliminate the effect of customs duties, but this is not so easy in the case of the indirect effects of the various taxes. One example of such indirect effect is that of a sales tax on butter on the selling price of margarine.[7] The case is very similar for subsidies. It is simple to correct the subsidized price of a product when the subsidy is direct, but almost impossible if it is the indirect result of other measures, such as would be the case if a raw material were obtained cheap because transport was subsidized.

Taxes or subsidies may not be obvious, even though direct, as is often the case with exchangee and public service rates. An examination is made below of methods of eliminating taxation or direct subsidies implicit in exchange rates. Public service rates involve a subsidy to the degree in which income fails to cover the costs of the enterprises providing the service.

#### (b) *Exchange rates*

In a project study, income or expenses in foreign exchange must be converted into national currency, which involves the application of a specific exchange rate. If the rate actually used for each transaction is applied, the pricing will not always reflect the true cost of the respective goods or services. At times Governments set a greatly over-valued exchange rate, in order to avoid increases in the price of imports, to reap some of the profits from the export of certain goods, or both. Conversely, under-valued rates may be set to discourage imports of certain goods or to encourage marginal exports. To eliminate the effect of these levies or subsidies on evaluation calculations, the true exchange rate must be sought, whereby to measure the extent to which the prevailing market rates are over- or under-valued. If the foreign exchange market were completely free and this also included freedom from quantitative restrictions, such as import and export quotas, for example, it is possible that the market forces would establish an equilibrium rate which did not include either levies or subsidies. This, however, is not always the case, and thus the problem arises of correcting the exchange rate so that it reflects the social cost.

A number of practical solutions have been suggested for the quantitative representation of the equilibrium exchange rate or "social exchange rate". One uses the weighted average of all import and export rates. This is based on the theory that, although in practice there are many exchange rates, not all will be over-valued nor all under-

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[5] A recent study by Professor Tinbergen proposes the use of "accounting prices", which would be the technical instruments to ensure full use, and not more than full use, of the scarcer available production factors. These prices are the intrinsic value of the factors, and using them, the supply is exactly sufficient to meet the the demand. Professor Tinbergen says that accounting prices represent the value of the marginal product which they help to produce, since projects which do not show a surplus over the cost of the factors employed (at accounting prices) will be marginal between acceptance and rejection. (Jan Tinbergen. *The Design of Development,* a report prepared for the International Bank for Reconstruction and Development, Washington D. C., February 1957. See also below Professor Chenery's thesis.)

[6] This correction of market prices for evaluation purposes does not imply disregard of the fact that the community must pay taxes for financing Government services. What it really implies is that the comparative appraisal of projects should not be affected by the manner in which the burden of taxation is distributed. Thus variations in the amount of sales tax, or the list of goods or services to which it is applicable, can vary the apparent productivity of projects employing such goods or services, distorting their relative position in the priority scale, although there have been in fact no changes in productivity. Similar observations may be made as regards subsides, inasmuch as they are "negative taxes".

[7] The higher the tax, the higher the price of margarine. If the representative price of butter is taken as that which results from the subtraction of the sales tax from the market price, this underestimates the value from the point of view of the consumer. If this tax was abolished, the price would really be higher than this difference, since many consumers who turned to margarine because of the tax would consume butter again.

valued. Thus, although the average would not be completely free from these effects, it will always be nearer to the equilibrium rate than any actually in force. The objection to this theory is that all the rates may conceivably be either over- or under-valued, or at least, the majority of them, and to use the average might then introduce an error greater than that which it sought to correct.

A solution has also been sought in the use of the "parity rate", calculated on the basis of the theory of the purchasing power of the different currencies, as explained below.

The index of purchasing power of a currency in its own country is the reciprocal of the price index: the higher the price levels, the lower the purchasing power.

The theory of parity of purchasing power of a currency assumes that, other factors being equal, the relative variation of the exchange rate between currencies will be proportional to the relative variation of the purchasing power in the respective countries.[8]

For example, take the case of country A, whose currency is the peso, and country B whose currency is the dollar, where the relation "pesos per dollar" at any given moment would be given by the expression:

$$\text{Exchange rate in pesos per dollar} = \frac{\text{purchasing power of the dollar}}{\text{purchasing power of the peso}}$$

If the ratio were 2, this would indicate that the purchasing power of the dollar is double that of the peso and that 1 dollar or 2 pesos will buy the same quantity of goods or services in A or B.

Assuming now that this purchasing parity corresponds to a specific monetary equilibrium and balance-of-payment situation in A and B, and that with the passage of time the prices move unequally. The parity of equilibriun would then change in accordance with the relative variations in the respective internal purchasing powers of the currencies. If the price index of A moves, for example, from 100 to 125, while that of B remains unchanged, then the relation between the two purchasing powers, and therefore the parity exchange rate, would no longer be 2. The new purchasing power of the peso would be 80 per cent of the previous rate $\left(\frac{100}{125}\right)$ since, by definition, it is the reciprocal of the price index. Yet the purchasing power of the dollar would continue to be 2. The new exchange rate would be:

$$\text{Exchange rate} = \frac{2.00}{0.80} = 2.5$$

*Example 5.* Table XXV illustrates a case, based on fact where price indices have varied in the two countries. Taking 1937 as base year, 100 will represent the internal price index in both country A and country B and also the price ratio, or what is in fact the same, the purchasing powers in that year. The equilibrium exchange rate in force in the base year was 85 pesos per dollar; in 1954, it was officially fixed at 215. Nevertheless, according to the purchasing parity, the true exchange rate for 1954 would be 243.7 pesos per dollar. In fact, while the price index in A rose from 100 to 322.5, that in B rose from 100 to 112.5. Consequently, the ratio between the purchasing powers changed from the 1937 values of 85 in A and 1 in B to 85 $\left(\frac{100}{112.5}\right)$ and 1 $\left(\frac{100}{322.5}\right)$ respectively.

The new ratio between the purchasing power in 1954 became:

$$\frac{85\,\frac{100}{112.5}}{1\,\frac{100}{322.5}} = \frac{85 \times 322.5}{112.5}$$

The ratio $\frac{322.5}{112.5}$ is 2.867 and reflects the increase of the ratio of the price indices from 100 to 286.7, indicated in item III of table XXV. The mechanics of the operation for calculating the parity exchange rate are simple, since it is sufficient to multiply the exchange rate for the base year, assumed to be equilibrium, by the ratio of the price index also for the base period.

Apart from the fact that the other factors must be equal, the main problems arising from the calculation of the parity rate consist in selecting the so-called "normal period", which is used as a basis for comparison (1937 in the table) and the price indices to be used. No general rules can be laid down regarding these problems. The most appropriate solution will depend upon the country concerned.

### 3. *Opportunity cost*

Many economists do not consider the correction of market prices purely by means of levies or subsidies to be an altogether satisfactory solution. The problem which they present is the alternative use of resources and their diversion from lower to higher productivity levels. They approach this problem by using the already defined concept of opportunity cost. This concept will first be examined pragmatically in relation to some important factors, and then the theory of linear programming will be explained.

#### (a) *Labour*

A high level of unemployment does not necessarily lead to a decline in wage rates, since legal minimum rates may be established, or collective contracts or other factors may have their effect. Hence market prices do not reflect the social cost of labour.

**Table XXV**

EXAMPLE 5. CALCULATION FOR COMPUTING PARITY EXCHANGE RATE

(1937 = 100)

| | *1937* | *1954* |
|---|---|---|
| I. Domestic price index in country A (peso) | 100 | 322.5 |
| II. Domestic price index in country B (dollar) | 100 | 112.5 |
| III. Index of the price ratio $\frac{A}{B}$ | 100 | 286.7 |
| IV. Prevailing exchange rate | 85 | 215.0[a] |
| V. Parity exchange rate | 85 | 243.7[b] |

[a] Exchange rate fixed by Government decision.
[b] The value 243.7 is the product of 2.867 × 85.

[8] The "other factors" are connected with the supply and demand of foreign currency and among them may be mentioned, the propensity to import, and the level of income and contributions from abroad in any form.

If, for instance, a road is to be constructed and there is unemployed labour which can be utilized without involving a reduction of output in other sectors of the economy, the price which must be paid for such labour employed on the road does not represent a social cost. A less obvious but similar case would be a new factory where a high level of productivity per man is anticipated, but which has to employ labour previously occupied in very low productivity agricultural work. The wages which the factory would have to pay truly represent the worker's contribution to the value of the manufactured production, but the sacrifice involved in diverting such labour to the industry consists in the fact that it was withdrawn from agricultural production and is equivalent to the wages paid to these workers in the latter activity. These wages would be the opportunity cost of the previously agricultural and now industrial labour.

It is not easy to determine the opportunity cost of labour. When endeavouring to prepare any industrial project, it must be asked from which activity labour will be diverted for employment in the project and what, therefore, society's loss of production will be as a consequence of the project. For example, the fact that a new textile mill obtains its personnel by recruiting them from domestic service may result in the domestic posts being filled by workers from rural areas. The loss of production would not in this case be in domestic service but in foodstuffs and agricultural raw materials, and in the latter there may also be displacements between different levels of productivity. The sacrifice or social cost of the new industrial labour would be in fact the contribution to their former occupation of the labour diverted from agricultural work.[9]

The calculation of the opportunity cost of labour leads to additional complexities, even where unemployment exists. Suppose, for example, that at a given moment there are 100 000 workers unemployed and that the State approves investment programmes which will absorb 90 000. If no other production is sacrificed to supply this labour, the opportunity cost will be 0. Suppose, on the other hand, that the private sector has plans which will employ 20 000 more workers, so that there will be new employment opportunities for 110 000 persons, against an unemployed pool of only 100 000. There is then some uncertainty as to which of the projects will occupy unemployed labour, and which will obtain personnel from other activities. A practical solution would be to consider as opportunity cost, in a given case, the average income of all unskilled labour in the country or area, calculated by dividing total wages paid by the total number of workers, whether employed or not.

It is evident then that development programmes will affect a specific labour supply and demand situation and hence its future opportunity or social cost.[10] In under-developed countries, the market price of labour will always be greater than the social cost.

The practical limitations in applying the concept should always be remembered, and no unjustifiable refinements should be attempted in the modification of market prices. The following criteria might be applied among others:

(i) Consider the difference between installation and production costs. If the site of the project is known, together with employment conditions and the time required for construction, it will be comparatively easier to estimate the social cost of the labour employed in the installation work. If there were any certainty that some of the labour employed would be previously unemployed, and that there were no possibilities of placement in other activities, a social cost of zero might be assigned. This may occur, for example, in the case of projects which take advantage of seasonal agricultural unemployment.

(ii) The greater differences between social cost and market price occur for unskilled labourers and non-specialized employees.

(iii) In general the adjustment of the market cost of labour will be all the more justified and important the greater the difference between labour productivity sectors, and when the structural conditions causing the overt or disguised unemployment are more deep-rooted.

(iv) In the absence of more specific data, a percentage of the market price may be adopted, based on available criteria, and adapted to all labour in all projects under comparison, without taking into account technical or site differences. These percentages may be changed later, in order to see what effect the changes would have on the final order of priority of the projects.

(b) *Capital*

The same problem may arise in connexion with the cost of capital, that is to say, interest rates, since these are usually fixed by special regulations. Because of the shortage of capital in under-developed countries, the real cost of using capital will most probably often exceed the maximum cost authorized by the law or other regulations. Just as a surplus of supply over demand in labour leads to its social cost being lower than the market price, so does the relative shortage of capital lead to a rate of interest higher than the market one.

According to the explanation of financial equivalences, given when speaking of the homogeneization problem, the interest rate plays a very important part in evaluation, and a variation in the rates used in the calculation may therefore affect the order of priority of the projects. If the great difference which may exist between the market rate and that resulting from the free play of supply and demand is not taken into account in the calculation, serious errors may be incurred in allocating priority to projects with a relatively high capital intensity in relation to national availability of capital and labour.

It is more difficult to determine this true or social rate of interest than in the equilibrium exchange rate. Nevertheless, a relatively arbitrary estimate will sometimes be preferable to the use of the market rate.[11]

(c) *Natural resources*

The argument may be extended to other factors, such as land. The opportunity or replacement cost of the use of

[9] This gives some idea of the inter-connexion between the problem of opportunity cost and that of the project's indirect effects.

[10] As was mentioned earlier, Tinbergen (*op. cit.*, note 5.) uses "accounting prices" which reflect the price of labour needed to achieve full employment under conditions of equilibrium. Acknowledging the difficulties involved in measuring the consequences of investments on future accounting prices, Tinbergen considers that a rough estimate may be sufficient for the actual fundamental disequilibrium affecting the market price (especially overt or disguised unemployement in under-developed countries). The project is therefore evaluated using a certain percentage of the average market rate for wages (60, 70 or 80 per cent).

[11] Tinbergen, *op. cit.*, states that some indications of the "equilibrium" rate of interest may be obtained from: (*a*) the rates at which it will be possible to attract additional capital; (*b*) the profitability of marginal projects, corrected for risks such as inflation. If no background information is available, the calculation may be made with 10 per cent interest or more, even for the sole purpose of analysing the results.

land in an agricultural project would be the loss of production from that land, arising from its diversion from its previous use. This is not so simple as it may appear. If a field is changed, say, from growing cereals to fruit, the production of cereals does not necessarily have to decrease. It may be that this crop was transferred to other land which had been less well employed, such as extensive livestock production. Thus the opportunity cost of the fruit-producing project will not be the amount which corresponds to the land factor in the growing of cereals, but that resulting from the use of the land for livestock production.

If idle land is available and the chain of successive crop displacements is followed, finally the idle land will be reached, giving an opportunity cost of 0.0. A programme of this type, which covers all the investments for the phases mentioned, will have no social cost for land use, even though it was necessary to pay the owner for the use of the idle land. To sum up, the fruit replaced the cereal, but the production of the latter was not reduced, since it replaced, say, an artificial pasture whose production was not reduced either because it was moved to natural pasture; nor would the production of the last-named be lost, since land previously unused is now employed for cultivation or livestock. The payment made to the owner of these latter lands is only a transfer and does not constitute a social cost.

If only an individual project is being considered, the opportunity cost for the use of the land will be the part attributable to the land factor in the production which was previously obtained from that piece of land. This cost could be the rentable value of the land when used for that purpose.

In the case of natural forests or mineral deposits, it must be remembered that, although they have no immediate alternative use, that is to say, although the social cost is 0.0, their use in any project involves the gradual consumption of an asset. It therefore appears advisable to include in the evaluation a reserve to cover the renewal of that asset. Such a procedure would, however, tend to retard the employment of the natural resources, since the projects would have lower priority if the natural resources were calculated with any value greater than 0.0, which is their opportunity cost. For social evaluation purposes, it appears preferable to exclude from the costs the reserves for depletion, even though they must be included in the project's normal accounting and in the evaluation from the private point of view. To ensure that the consumed asset is replaced by reafforestation or through new investments is a problem of economic policy which should not affect the comparison of the intrinsic productivities of the projects.

The case of mineral deposits is somewhat different from that of forests. In general, to confirm the existence of mineral reserves society incurs costs, among which are surveying, prospecting, identification and estimating the volume of the reserves. The effective cost of these operations is that which must be computed for social pricing purposes. This means that the remuneration of the private mining entrepreneur who makes a lucky find, which is seen for instance in the profit from the sale of the mine, is not considered as social cost.

### (d) *Equilibrium prices*

The problem of pricing and priorities is discussed by Professor Hollis B. Chenery as follows:[12]

It may be demonstrated that businessmen's profitability calculations induce them to make investments which are also optimum from the social point of view, provided that: (i) as an *a priori* condition, the economy is stable; (ii) the economies of scale are small; (iii) changes in a sector's production have been duly anticipated by investors in another sector. These conditions can only ensure that maximum output will be obtained from a given quantity of resources; social welfare may, of course, be enhanced by means of income redistribution.

Precisely because some or all of these conditions are not fulfilled in under-developed countries, the profit calculations made by businessmen require a certain amount of correction. Nevertheless, in order to understand the nature of the different evaluation criteria, the function of prices in a system of competitive equilibrium should first be explained.

If, in the case of a given economy, perfect equilibrium exists, the market forces will act in such a way that the prices of goods will be equal to the marginal cost of raw materials, labour, capital and other inputs required in production. In their turn, the prices of labour, capital and foreign exchange will be equal to the opportunity cost of the respective factors, such cost being defined as the amount by which production would be reduced in an over-all economy if the availability of such inputs were to decrease in a unit. The prices of labour, capital and foreign exchange are therefore those which will balance supply and demand in relation to these factors. If the economy is expanding and everything is properly foreseen, prices will also reflect future demand and supply in such a way that equilibrium will be maintained over the long term.

If these ideal conditions were fulfilled, investment criteria based on the productivity of a single factor and on the productivity of all factors employed would be equally applicable. In order to calculate the various partial criteria, the cost of certain inputs (local materials, labour, imports, etc.) must be deducted from the total value of production, and the difference thus obtained attributed to the use of the other inputs. Partial productivity would thus be measured by dividing the value of production (measured by the above-mentioned difference) by the value of the last-named inputs (in relation to a specific use).

The procedure to be adopted is illustrated here by a hypothetical example in which four possible ratios of partial productivity are estimated (see table XXVI).

In this example, production is 100 in both projects. In project A, the total cost of inputs is 105, if capital cost is taken to be the marginal productivity of capital in other uses, i.e. its equilibrium price (0.25). In project B, the value of inputs, again on the basis of the equilibrium price of capital, and the value of production are identical.

Projects A and B may be compared by means of their total profits (—5 in the case of A and 0 in the case of B) or by means of the four productivity ratios shown in the table. Any one of these five measurement procedures shows that project B is preferable to A. The higher total cost of inputs in A is transformed into a lower productivity level for one input or all of them when equilibrium prices are used as a basis for evaluation. Whatever the input proportions, all the productivity measurements indicate the same priority. Hence, it is equally correct to say that, in B, labour productivity is higher, or that the productivity of total inputs is higher, provided that the value

[12] The author's permission has been obtained to reproduce these paragraphs, which were specially drafted as a commentary on the text of the *Manual.*

**Table XXVI**

VARIOUS INVESTMENT CRITERIA AT EQUILIBRIUM PRICES

| | *Project A* | *Project B* |
|---|---|---|
| Materials purchased | 35 | 34 |
| Depreciation (5 per cent) | 5 | 6 |
| Labour: | | |
| (i) Number of units | 200 | 150 |
| (ii) Cost (at 0.2 each) | 40 | 30 |
| Capital: | | |
| (i) Number of units | 100 | 120 |
| (ii) Cost (at 0.25 each) | 25 | 30 |
| Gross value of production | 100 | 100 |
| Profits | —5 | 0 |

*Productivity of*:

| | *Project A* | *Project B* |
|---|---|---|
| (*a*) Labour | $\frac{100-(35+5+25)}{200}=0.175$ | $\frac{100-(34+6+30)}{150}=0.20$ |
| (*b*) Capital | $\frac{100-(35+5+40)}{100}=0.20$ | $\frac{100-(34+6+30)}{120}=0.25$ |
| (*c*) Labour and capital | $\frac{100-(35+5)}{40+25}=0.92$ | $\frac{100-(34+6)}{60}=1.00$ |
| (*d*) All inputs | $\frac{100}{105}=0.95$ | $\frac{100}{100}=1.00$ |

of the inputs omitted is duly deducted from the value of production.

## 4. *Practical limits of social pricing*

Bearing in mind the foregoing considerations, the problem of social pricing may be summarized as follows:

(*a*) It arises because the factors may be calculated both at market prices and at so-called social prices; pricing at market prices will also be necessary in any event;

(*b*) For all practical purposes, when calculating the social pricing of a project, it will normally be sufficient to consider the following factors: (1) exchange rates; (2) indirect taxes and customs tariffs; (3) special subsidies and transfer payments; (4) opportunity cost of labour and capital and, in some cases, of natural resources;

(*c*) The specific items whose market prices are most frequently subject to variation are: (1) imported machinery and equipment, where exchange rates and customs duties must be taken into consideration; (2) items notably affected by indirect taxation—this would be the case of sales taxes on cement, iron or other materials employed in the construction of the project; (3) labour; (4) production factors used in the project, especially natural resources, which have no alternative use (for example, sand, stone, natural forests, minerals which have not required any special prospecting or surveying, water, etc.).

It will be useful to consider what degree of accuracy should or must be employed in social pricing. If data are not available for a reasonable estimate of opportunity costs, there will be no object in preparing a formal social pricing without any true economic meaning; it will be preferable in this case to limit the work to correcting market prices in order to eliminate the effects of taxes and subsidies.

Considerable difficulty results from the fact that projects must be evaluated for their entire useful life, which requires estimates of future selling prices. The longer the life of a project, the less reliance can be placed on projections, especially of social costs, because of structural changes arising from economic development with their consequent effects on the current situation.[13]

A practical solution would be to convert the projected expenses at market prices into social costs by applying the same ratio between these two as that estimated for the current situation. It must be left to the programmers to decide upon the advisability or inadvisability of applying this solution in each case.

Finally, it should be kept in mind that, if social pricing is applied to only a few of the factors, the priority relationship between projects may differ from that which would have resulted from its applications to all factors.

In spite of its limitations, social pricing provides useful data for the appraisal of the project's priority and for indicating the type of measures necessary to ensure that certain projects, with high priority according to the social evaluation coefficients used, also become attractive to the private entrepreneur.

## 5. *Calculations of social pricing in a hypothetical case*

*Example 6.* Table XXVII shows the calculations required in order to determine the volume of investment

[13] Tinbergen (*op. cit.*), speaking of the accounting prices which he proposes, warns that, at least in principle, they can be estimated only for complete programmes and not for separate projects. Chenery advances the same idea in connexion with the computation of equilibrium prices with the aid of linear programming.

**Table XXVII**

EXAMPLE 6. SOCIAL AND MARKET PRICES OF A HYPOTHETICAL PROJECT

| | *Cost in dollars* | *Rate of exchange (monetary units per dollar)* | | *Costs in millions of monetary units* | | *Difference (A—B)* |
|---|---|---|---|---|---|---|
| | | *Official* | *Parity* | *Market (A)* | *Social (B)* | |
| I. Imported equipment c.i.f. | 100 000 | 200 | 300 | 20.0 | 30.0 | —10.0 |
| II. Customs | | | | 5.0 | — | 5.0 |
| III. Locally manufactured equipment | | | | 10.0[a] | 9.5[a] | 0.5 |
| IV. Miscellaneous materials for other intallations and buildings | | | | 20.0[b] | 18.0[b] | 2.0 |
| V. Unskilled labour, previously unemployed | | | | 10.0 | 5.0 | 5.0 |
| VI. Skilled labour | | | | 3.0 | 3 | — |
| VII. Foreign technical assistance | 20 000 | 500 | 300 | 10.0 | 6.0 | 4.0 |
| VIII. Administration and supervision | | | | 5.0 | 5.0 | — |
| *Total* | | | | *83.0* | *76.5* | *6.5* |

[a] A sales tax of 5 per cent has been assumed on the equipment (round figures).
[b] A sales tax of 10 per cent has been assumed for these materials (round figures).

in a hypothetical project, both at market prices and at social costs; the values are expressed in unspecified monetary units. According to market prices, the investment amounts to 83 million as against 76.5 million according to the social cost. It may be seen that the differences—shown in the last column of the table—are due to the different exchange rates used, the omission of taxes and the lower opportunity cost of labour.

The true social exchange rate has been estimated at 300 monetary units per dollar by applying an assumed parity calculation. The official exchange rate for importing equipment is 200 units per dollar, which implies subsidizing this equipment to the extent of 10 million monetary units. Customs duties are 5 million and are not included in the social pricing. The abolition of sales taxes on locally manufactured equipment reduces the investment at social prices by half a million units; this item reduces the investment under "miscellaneous materials" by 2 million units below the market price.

The unskilled labour employed in construction and installation would cost 10 million at market prices, but only 5 at opportunity cost. An exchange rate of 500 units per dollar has been assumed for the payment of foreign technical services, but the social cost would be only 300. This reduces the social cost by 4 million monetary units. Taxes deducted for the calculation of social cost (items III and IV) are those directly imposed on the transaction between the enterprise which makes the investment and its suppliers. Consequently, no attempt has been made to deduct taxes which suppliers pay in the production of the goods in question. In all, the social price of the investment is 6.5 million less than at the market price.

Assuming that these investments have an average useful life of 20 years and that they are placed in a manufacturing industry whose balance of income and expenditure, without considering depreciation and interest, is as shown in tables XXVIII (expenditure) and XXIX (income), where the opportunity and market costs of labour will be equal.

**Table XXVIII**

EXAMPLE 6. ANNUAL EXPENDITURE IN OPERATING THE INDUSTRY, WITHOUT DEPRECIATION

| | Dollars | *Rate of exchange (Monetary units per dollar)* | | *Costs in millions of monetary units* | | *Difference (A—B)* |
|---|---|---|---|---|---|---|
| | | *Official* | *Parity* | *Market (A)* | *Social (B)* | |
| I. Imported raw material, miscellaneous materials, fuel and spares. . . . . | 60 000 | 100 | 300 | 6.0 | 18.0 | −12 |
| II. Customs duties. | | | | 1.0 | — | 1 |
| III. Domestic raw material, miscellaneous materials, fuel and spares. . . . . | | | | 30.0 | 28.0 | 2 |
| IV. Salaries and wages. . . . . | | | | 18.0 | 18.0 | — |
| V. Taxes, rates, insurances, and miscellaneous . | | | | 4.0 | 3.0 | 1 |
| *Total* . . . . . . . | | | | 59.0 | 67.0 | −8 |

**Table XXIX**

EXAMPLE 6. ANNUAL INCOME

| | *Exchange rate (Monetary units per dollar)* | | *Amount (dollars)* | *Income in millions of monetary units* | |
|---|---|---|---|---|---|
| | *Official* | *Parity* | | *Market price* | *Social value* |
| I. Exports. . . | 400 | 300 | 20 000 | 8.0 | 6.0 |
| II. Domestic sales. . . . | — | — | — | 60.0 | 60.0 |
| *Total*. . . . . | | | | 68.0 | 66.0 |

Table XXVIII shows that the annual expenditure at social prices is 8 million higher than at market prices, that is to say, in the final balance of payments made and received, the enterprise benefits, according to market prices, by 8 million annually. As may be seen, this is entirely due to the exchange rate subsidy, since the raw material is imported at 100 units per dollar, whereas the parity exchange rate is 300. Customs duties and other taxes do not compensate for the heavy subsidy incorporated in the exchange rates for importing raw materials and other items.

It should be noted that four exchange rates have been used so far:

| | *Units per dollar* |
|---|---|
| For imported equipment . . . . . . . . . | 200 |
| For payments for foreign technical services. | 500 |
| For imports of raw materials . . . . . . | 100 |
| True social exchange rate . . . . . . . . . | 300 |

This situation may appear to be exaggerated, even in a hypothetical case, to readers who have had no experience in this type of problem. Yet it is very representative of true cases in Latin America and has been chosen as an example since from there it is easier to pass on to simpler cases.

As regards annual income (table XXIX), it will be seen again that the industry is favoured by the export exchange rates, which in practice amount to a subsidy of 2 million annually. It has been assumed that something under 14 per cent of the output is exported.

Table XXX summarizes income and expenditure.

If it is desired to know the losses which the project would incur according to social pricing, all figures may be reduced to present worth on the original date. The calculation of the present worth of an annual series for 20 years, at a conventional interest rate of 6 per cent, consists in multiplying the annual value by the present worth factor (11.47). Consequently, the present worth of income, at social prices, would be 757 million and of expenditure

**Table XXX**

EXAMPLE 6. ANNUAL INCOME AND EXPENDITURE, EXCLUDING DEPRECIATION AND INTEREST

*(Millions of monetary units)*

| | *Method of pricing* | |
|---|---|---|
| | *Market* | *Social* |
| Income. . . . . . . . . . . . . . | 68.0 | 66.0 |
| Expenditure. . . . . . . . . . . . | 59.0 | 67.0 |
| *Annual net income* . . . . . . . . . | 9.0 | −1.0 |

768.5 million. The expenditure and the fixed investment are added in table XXXI.

At 6 per cent interest, the project would show a total social loss of 88 million units, converted to present worth at the initial date, while at market prices, the profit would be 20.5 million.

If the social cost of labour throughout the useful life is estimated at 80 instead of 100 per cent of the market value and if the interest were 10 per cent instead of 6, the final results would be those shown in table XXXII.

Although the social operating costs are now lower, calculation of present worth at 10 per cent interest reduces the total income below the total costs.

**Table XXXI**

EXAMPLE 6. PRESENT WORTH OF THE FIGURES AT 6 PER CENT INTEREST

*(Millions of monetary units)*

| | *Market prices* | *Social costs* |
|---|---|---|
| Present worth of the annual costs. . . . | 676.5 | 768.5 |
| Fixed investment. . . . . . . . . . . | 83.0 | 76.5 |
| Total costs. . . . . . . . . . . . . . | 759.5 | 845.0 |
| Total present worth of income. . . . . | 780.0 | 757.0 |
| Present worth of losses (−) and profits (+). . . . . . . . . . . . | + 20.5 | − 88.0 |

**Table XXXII**

EXAMPLE 6. FINAL BALANCE OF THE PROJECT WITH THE SOCIAL COST OF LABOUR EQUAL TO 80 PER CENT OF THE MARKET PRICE, AND WITH PRESENT WORTH CALCULATED FOR AN INTEREST RATE OF 10 PER CENT

*(Millions of monetary units and round figures)*

| | *Annual pricing* | | *Total pricing at present worth* | |
|---|---|---|---|---|
| | *Market* | *Social* | *Market* | *Social* |
| Operating costs. . . . . . | 59.0 | 63.4 | 502.0 | 540.0 |
| Initial investment. . . . . | — | — | 83.0 | 76.5 |
| Total costs. . . . . . . . | | | 585.0 | 616.5 |
| Income. . . . . . . . . . . | 68.0 | 66.0 | 579.0 | 562.0 |
| Losses (−) or profits (+) | + 9.0 | + 2.6 | − 6.0 | − 54.5 |

## III. Indirect effects

### 1. *The pragmatic approach*

Each project sets up a chain of reactions which, although gradually diminishing in intensity, will always have quantitative effects over a wide field. The measurement of a project's indirect effects may present extremely difficult problems, because the project eventually has an influence, however slight, on the whole of the economy.

If a detailed input-ouput table were available, it could be used to estimate the final effects of the introduction of this or that variation represented by a given project. Normally such tables are not available; those which may be prepared in the near future in under-developed countries will certainly be limited to very few sectors, suffcient for projections of the integral programme, but inadequate for making estimates for a specific project. In practice, therefore, it must be assumed that no such data will be available for the measurement of indirect effects.

The alternative is to make some kind of approximate estimates, which, although imperfect and not reflecting all the indirect effects of a project's execution, will at least be better than consideration of the direct effects alone. What these estimates will be and how they will be made will naturally depend on the projects themselves and on actual circumstances. As a general rule, an attempt will be made to take a "backward" look towards the source and a "forward" look towards the destination of the project to see what the effects might be according to the evaluation criterion applied.

The magnitude of indirect effects on the project's social evaluation, both in terms of benefits and of resources utilized, will vary according to the type of project. Generally speaking, projects providing basic services for production will be justified by their effects on the rest of the economy rather than on the outcome of the project itself. The technical and economic characteristics of power stations, for example, mean that their direct contribution to national production per unit of investment or of total input is low, but consideration of the benefits deriving from the execution of such projects often shows that they are of top priority. Similar considerations may also apply to transport services.

The result of the indirect effects will differ if the project is, for example, a caustic soda factory. The differences include the following: (*a*) the use of electricity or transport is very widespread and forms a virtually indispensable input in all productive processes, whereas soda is an input in a much smaller number of activities; (*b*) with certain exceptions, as yet unknown in Latin America, electricity must be produced in every country, that is, it cannot be imported, whereas soda and other similar products can be imported; the indirect benefits resulting from the availability of soda end with its production and sale to users, since from that point on it is immaterial whether the product is domestic or imported. There will certainly be some "backward" effects, but they will rapidly lose their force, and will be limited to a small number of productive factors.

The method of considering indirect effects will also depend upon the evaluation criterion applied, which will present differing conceptual and measurement problems. The problem will thus be different when measuring indirect effects on the balance of payments, employment or the national product.

To sum up, the above reasons make it preferable to approach the problem of direct and indirect effects when dealing with each individual criterion. The brief comments made here do not imply that the importance of this problem is being under-estimated, but that, on the contrary, in view of its extraordinary range and wide implications, it is preferable to discuss it in relation to each separate criterion.

One special type of indirect effects develops from the effects which a new producer will have on the volume and distribution of national income. The chain of transactions arising from the project will become a certain total contribution to the national income which will be distributed according to a certain pattern.[14] These effects on income may in turn affect processes such as the formation of savings, the volume of imports or the Government's revenue from taxes. Similarly, if some projects in the public sector require subsidizing, changes are introduced in the movement of national income, which may also affect the formation of savings or import trends.

This type of indirect effects of the project have been named secondary effects or consequences;[15] they are difficult to measure and only "illustrative estimates" can be made.

The secondary effects will vary, for example, with alternatives of differing capital or labour intensity in a given project, as will be appreciated when dealing with the productivity of capital. They will also enter into the explanations of the project's effect on the balance of payments.

### 2. *Equilibrium prices and their indirect effects on linear programming*

There is a very interesting theoretical approach to the problem of measuring the indirect effects of a project, both "backwards" and "forwards", which makes use of linear programming concepts. The following outline, which was mentioned earlier in the *Manual*, is a summary by Professor Chenery of his ideas on this subject.[16]

The different investment criteria attempt to offset the gap between real prices and equilibrium prices in two ways:

(i) By making the necessary adjustments so that due attention is given both to the values produced and to costs incurred outside the project but deriving from it; in other words, so that indirect costs and benefits are taken into consideration;

(ii) By adjusting prices, i.e. using social or accounting prices instead of market prices.

These two methods of adjustment are alternatives, even though they may be used in conjuction. If it were possible to discover the prices corresponding to the system of equilibrium that would prevail after the investment programmes had been put into effect, there would be no need to study indirect costs and benefits. This method of tackling the problem consists of mathematical programming, but it cannot be properly carried out in under-developed countries because the data at present available in these countries are inadequate.[17] In any event, in so far as the opportunity costs of inputs and the equilibrium price of the goods produced could be determined, it would be possible to avert the need—usually more speculative—to calculate indirect effects.[18] For instance, one of the main sources of benefits derived from or produced by the operation of a project is the utilization of labour or other idle resources. Nevertheless, if the real opportunity cost of these resources is used to determine the inputs purchased by the project, full account will be taken of the indirect benefits. Likewise, the only reason for investigating the project's "forward" indirect benefits is that production will be under-valued if it is calculated at market prices. The use of a price that will reflect the opportunity cost of the same level of production obtainable from other sources is once again the alternative to investigating the indirect effects.[19] As the total value of production in a project, when conditions are stable, is reflected in its market prices, no "forward" indirect benefits would result from the execution of the project. Similarly, the market price of inputs would not differ in this case from their social cost and there would be no "backward" indirect benefits. Indirect benefits are therefore entirely the result of separation from conditions of competitive equilibrium.

In the case of external economies which arise from the interdependence of investment decisions,[20] prices in a perfect market would not necessarily give the right result, particularly when economies of scale are also involved in the problem.

As, owing to the inclusion of equilibrium prices in pricing calculations, the various productivity criteria give the same results, the choice of criterion depends on the extent to which the accounting prices used resemble the true equilibrium prices and on the nature of the difference between them. This difference can be determined only by experimenting with specific cases, and it might be advisable to calculate several alternatives to see whether they really conflict with one another, i.e. to see whether they would indicate a different order of priority for the projects. But as the opportunity cost of capital cannot be established until a trial programme has been set up for the whole economy, it might be preferable, in allotting priorities, to measure the productivity of the input complex by means of capital productivity rather than any other index.

It should nevertheless be stressed that the choice of a priority criterion ought to rest on the fact that the calculations are easy to make and that the approximate method probably comes nearer than any other to the abstract ideal.

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[14] There will be no contribution if the project only involves the use of resources which would have been employed in any case.

[15] See Tinbergen, *op. cit.*

[16] The author's permission has been obtained to reproduce these paragraphs which were specially drafted by him as a commentary on the text of the *Manual*.

[17] Chenery has applied this technique experimentally, as he relates in "The Role of Industrialization in Development Programs", *American Economic Review*, May 1955, pp. 40-57.

[18] See the criticism by J. Margolis of the procedure used by the United States Bureau of Reclamation in "Indirect Benefits, External Economics, and the Justification of Public Investment", *Review of Economics and Statistics*, August 1957.

[19] The author explains that this possibility is very clear when the alternative source of supply consists of imports, but that the same principle is also applicable to domestic alternatives.

[20] A wide range of meanings has been given to the term "external economies". For this reason, Chenery explains that he has used it with reference to the economies which result from the interdependence of projects (see below, chapter III, footnote 35).

## IV. Final notes

### 1. *Practical limitations*

The evaluations problem is essentially one of comparison and priority, and there are two general methods of approach: (*a*) to present a series of impartial evaluation coefficients, so that those responsible for the decision have adequate data on which it may be based; and (*b*) to include all the economic effects of the project in a single formula in order to obtain a single coefficient, so that the decision will simply consist in placing the projects in the order of priority indicated by this "integral" coefficient.

From the practical point of view, it will be simpler to carry out the calculations required for obtaining partial evaluation coefficients in direct terms at market prices. The determination of social prices and the calculations of indirect effects are more serious problems.

Because of the difficulties already mentioned in social pricing, it will be advisable to limit estimates to the larger production factors, remembering that comparative terms are required and not absolute measurements. Since, at the same time, only a certain degree of approximation can be achieved in the whole of the project study even for strictly technical data, some tolerance must also be accepted in the evaluation calculations. In other words it must not be forgotten that a project involves an investment proposal which depends upon estimates, and which will always include calculated risks.

Possible price changes, the inevitable estimate of the project's useful life, the true depreciation (because of obsolescence), technical innovations, actual development of demand and other items, are unknown factors which limit the accuracy of the general calculations of the project and hence its evaluation.

On the other hand, it is obvious that without these calculations there is no way of making a comparative appraisal of projects nor of taking rational decisions; the alternative of leaving the field open entirely to intuition or bias is patently worse.

These are the perspectives in which the evaluation problem and the attainable degree of accuracy must be judged. In view of these limitations, on the one hand, and the unavoidable necessity for evaluation on the other, it must be acknowledged that in most cases the more or less subjective consideration of a series of partial coefficients must replace the mathematical method represented by a single evaluation formula.

### 2. *Order of presentation*

For the guidance of the reader, it has been considered advisable to give him some advance information on the sequence adopted in the following pages to explain the various evaluation criteria. One of the previously mentioned classifications has been used despite its acknowledged limitations.[21] It is the one which considers, first of all, the criteria referring to the productivity of one single resource—whatever it may be—and, secondly, those relating to the productivity of the complex of resources required for a specific project. A third group will include criteria for establishing priorities among projects, combining and considering in some way various partial evaluation coefficients. It should be mentioned that this order does not imply any judgement on the relative importance of each group.

Among the criteria which apply to one single resource, the most important are undoubtedly those which measure the productivity of capital. Among these, in turn, a distinction should also be made between those which refer to the profitability of the project and those which express the social profitability of the capital. It has already been stated that the reaping of maximum profits is the standard normally used by the private entrepreneur and which must be computed for any project. Profitability is the most-used method of expression, and this criterion will therefore be described first. This will be followed by the social criteria of productivity of capital and those affecting a single productive factor in the denominator.

The second group will include the benefits-costs criteria and that advanced by Jorge Ahumada concerning the direct and indirect value added. The corresponding coefficients are integral and measure the productivity of the complex of input.[22]

Finally, the criteria proposed by K. A. Bohr and the Stanford Research Institute will be outlined, by which priorities are established by combining and weighting partial evaluation criteria.

[21] See chapter I, of this part.

[22] Since the previously-mentioned study by Tinbergen was not available when this *Manual* was completed, it was impossible to include here a description of the evaluation pattern proposed by that author. Only a few references to his text could be made in the form of footnotes.

# Annex

## Financial equivalences

### 1. *Concept of equivalence*

The following example serves to illustrate how the interest rate may produce equivalence between different amounts of money paid or received at various dates. Assume that 10 000 monetary units are to be paid off in 10 years at 6 per cent interest, according to any of the four procedures indicated below:

(*a*) The interest is paid off at the end of each year and the 10 000 monetary units are amortized in a lump sum at the end of 10 years. During each of the first 9 years, 600 units will be paid and in the tenth 10 600; the debt is thus repaid. Altogether, the payment will be 16 000 units for an initial value of 10 000. The initial 10 000 monetary units are economically equivalent to 16 000 paid out in the manner described, when the interest rate is 6 per cent.

(*b*) One thousand monetary units are amortized each year, and the 6 per cent interest is paid on that portion of capital which is not amortized as outlined in table 117.

At the same interest rate and over the same period, the initial 10 000 monetary units are equivalent to the 13 300 paid off as described.

(*c*) An annual quota is paid for interest and another for amortization, in such a way that the sum of both will be the same each year. The development of this method of payment, still at 6 per cent interest, is shown in table 118. The formula for calculating the total annual quota is explained later.

As table 118 indicates, the amortization quota increases each year while the interest quota decreases, so that the sum of both is always the same.

Interest is paid on the outstanding balance of the previous year; since this balance is declining (column A of table 118), the interest paid each year is also less. The total sum paid—13 586.8 monetary units in 10 years—is

**Table 117**

AMORTIZATION OF A CREDIT OF 10 000 MONETARY UNITS AT 10 YEARS IN EQUAL QUOTAS OF 1 000 AND INTEREST AT 6 PER CENT

| *End of year* | *Amount owed after year-end payment* | *Amortization* | *Interest* | *Total annual payment* |
|---|---|---|---|---|
| 0 | 10 000 | — | — | — |
| 1 | 9 000 | 1 000 | 600 | 1 600 |
| 2 | 8 000 | 1 000 | 540 | 1 540 |
| 3 | 7 000 | 1 000 | 480 | 1 480 |
| 4 | 6 000 | 1 000 | 420 | 1 420 |
| 5 | 5 000 | 1 000 | 360 | 1 360 |
| 6 | 4 000 | 1 000 | 300 | 1 300 |
| 7 | 3 000 | 1 000 | 240 | 1 240 |
| 8 | 2 000 | 1 000 | 180 | 1 180 |
| 9 | 1 000 | 1 000 | 120 | 1 120 |
| 10 | — | 1 000 | 60 | 1 060 |
| *Total* | | *10 000* | *3 300* | *13 300* |

equivalent to the initial 10 000 units, provided that it is paid out in the manner indicated and at 6 per cent interest. This amount is rather similar to that obtained with the preceding method of payment (13 300); this is not accidental and will always occur when the interest rates and the periods remain within certain limits. As the interest rate rises and the number of years increases, the differences will tend to be greater.

(*d*) A method of payment without intermediate payments can be adopted, so that both the principal and its compound interest are paid off at the end of 10 years. There is a formula for calculating the amount of this principal plus the compound interest, which in this particular case, would amount to 17 908.49 monetary units. At the end of the 10 years, a payment is made in respect of this amount, so that the debt plus its interest is paid off. Again there is equivalence between the initial 10 000 monetary units and the 17 908.49, if these are paid in the manner indicated.

Infinite amortization combinations can be conceived

**Table 118**

AMORTIZATION OF A CREDIT OF 10 000 MONETARY UNITS AT 10 YEARS SO THAT THE SAME ANNUAL QUOTA COVERS BOTH AMORTIZATION AND INTEREST

| *End of year* | *Amount owed after year-end payment (A)* | *Amortization (B)* | *Interest (6 per cent on the preceding year in column A) (C)* | *Total annual quota (B+C)* |
|---|---|---|---|---|
| 0 | 10 000.00 | — | — | — |
| 1 | 9 241.32 | 758.68 | 600.00 | 1 358.68 |
| 2 | 8 437.12 | 804.20 | 554.48 | 1 358.68 |
| 3 | 7 584.67 | 852.45 | 506.23 | 1 358.68 |
| 4 | 6 681.07 | 903.60 | 455.08 | 1 358.68 |
| 5 | 5 723.25 | 957.82 | 400.86 | 1 358.68 |
| 6 | 4 707.98 | 1 015.28 | 343.40 | 1 358.68 |
| 7 | 3 631.77 | 1 076.20 | 282.48 | 1 358.68 |
| 8 | 2 491.00 | 1 140.77 | 217.91 | 1 358.68 |
| 9 | 1 281.78 | 1 209.22 | 149.46 | 1 358.68 |
| 10 | — | 1 281.78 | 76.90 | 1 358.68 |
| *Total* | | *10 000.00* | *3 586.80* | *13 586.80* |

which would give as many different sums, all of them financially equivalent given the corresponding periods and the interest rate.

## 2. *Equivalence formulae*

### (a) *Symbols and formulae*

The more commonly used equivalences are calculated according to the following formulae: the symbols used are the following:[1]

i = Interest rate per interest year (or other period) expressed in relation to unity

n = number of interest years (or periods)

P = present sum of money (for instance, initial fixed investment subject to depreciation)

S = sum of money n interest years (or periods) from the present date that is equivalent to P at interest rate i

R = end-of-year (or period) payment in a uniform series continuing for the coming n periods, the entire series equivalent to P at interest rate i.

The formulae are:

$$(1) \qquad S = P\,(1 + i)^n; \; P = \frac{S}{(1 + i)^n}$$

$$(2) \qquad R = S\,\frac{i}{(1 + i)^n - 1}; \; S = R\,\frac{(1 + i)^n - 1}{i}$$

If in formulae (2) S is replaced by the value indicated in (1), then:

$$(3) \qquad R = \frac{P\,i\,(1 + i)^n}{(1 + i)^n - 1}; \; P = R\,\frac{(1 + i)^n - 1}{i\,(1 + i)^n}$$

Text on financial mathematics or engineering economy usually give detailed explanations of the development of these formulae. The method of deducing them will be indicated briefly here, because this will facilitate an understanding of the concept in which they are used in evaluation and in depreciation calculations.

### (b) *Formula (1): Equivalence between a principal P and a final capital S*

(i) *Deduction of the formula.* If a capital P is placed at compound interest i, at the end of the first year (or period) interests Pi will be added to it; the amount will become (P + Pi) or P (1 + i). At the end of the second year, the amount P (1 + i) with interest at rate i will have earned P (1 + i)i interest, becoming:

$$P\,(1 + i) + P\,(1 + i)\,i = P\,(1 + i)\,(1 + i) =$$

$$P\,(1 + i)^2$$

Similarly, at the end of the third year the amount will be $P\,(1 + i)^3$. After n years it will be $P\,(1 + i)^n$. If S is the value of P after n years, then

$$(4) \qquad S = P\,(1 + i)^n$$

(ii) *Single payment factors.* The factor $(1 + i)^n$ is

[1] The notation used is taken from Eugene L. Grant, *Principles of Engineering Economy*, 3rd edition, New York, The Ronald Press Co., 1950.

calculated in special tables for different values of i and n, and is termed the "single payment compound amount factor". It is sufficient to multiply a principal P by this factor to find the value of P after n years at compound interest i.

Separating P, then:

$$P = \frac{S}{(1+i)^n} = S\,\frac{1}{(1+i)^n} \tag{5}$$

Formula (5) enables P to be calculated when the other data are known. It is the same as discounting, with compound interest, a sum S which will be valid in n years more. This is known as calculation of present worth. By applying formula (5), the present worth of a single amount can be found; there are other formulae, the deductions of which will be given later and which facilitate the calculation of present worth of a series of annual values, providing they are equal.

The factor $\frac{1}{(1+i)^n}$ is the single payment present worth factor and its value is also found in special tables. This is simply the reciprocal value of the compound amount factor. It is termed single payment because only the present worth of one amount can be calculated.

(c) *Formula (2): Equivalence between a uniform series of annual values R and a final value S*

(i) *Deduction of the formula.* To deduce this formula, it is assumed that an amount R is placed for n years at compound interest i, capitalized at the end of each year.

The amount R, invested at the end of the first year, will earn interest during (n — 1) years. According to formula (1), it will become $R(1+i)^{n-1}$. The payment made at the end of the second year will become $R(1+i)^{n-2}$, and so on successively until the final payment, at the end of year n, will be simply R.

After n years, there will be an equivalent equal to the sum of these partial accumulations. If this sum is S, then:

$$S = R + R(1+i) + R(1+i)^2 + \ldots + R(1+i)^{n-1}$$

$$S = R[1 + (1+i) + (1+i)^2 + \ldots + (1+i)^{n-1}]$$

The parenthesis is a geometric progression[2] whose sum equals $\frac{(1+i)^{n-1}}{i}$

Then

$$S = R\left[\frac{(1+i)^n - 1}{i}\right] \tag{6}$$

Separating R, then

$$R = S\left[\frac{i}{(1+i)^n - 1}\right] \tag{7}$$

(ii) *Factors in the uniform series.* An amount R invested at the end of each year for n years, at compound interest i, will be equivalent to an amount S at the end of the period of n years, the value of S being given in formula (6).

[2] The sum of a geometric series consisting of $S = 1 + a + a^2 + \ldots + a^n$ is $S = \frac{a^{n+1} - 1}{a - 1}$.

The factor

$$\left[\frac{(1+i)^n - 1}{i}\right] \tag{8}$$

is called the uniform annual series compound amount factor, and its value is also found in the tables.

Formula (7) facilitates calculation of the annual quota R that has to be invested during n years at interest i to obtain a sum S.

The factor

$$\left[\frac{i}{(1+i)^n - 1}\right] \tag{9}$$

is used considerably to calculate accumulative depreciations and is termed in the technical literature the "sinking fund deposit factor". Its value is the reciprocal of the previous one, that is of the uniform annual series compound amount factor, and is given in tables.

(d) *Formula (3): Equivalence between a series of annual values R and a principal P*

(i) *Deduction of the formula.* To obtain formula (3), the value S in formula (2) is replaced by its expression as given in formula (1). Thus

$$R = \frac{P\,i\,(1+i)^n}{(1+i)^n - 1} \tag{10}$$

Revising carefully the method used to reach expression (10), it will be found to mean the following: R is the amount that must be invested at the end of each of n consecutive years, at compound interest rate i, to obtain, at the end of these n years, the same result as would have been obtained with a principal P invested at the beginning of the period of n years at compound interest i. The principal P is thus equivalent to the uniform annual series R because both the principal P plus its interests and the series R plus its interests will give the same amount at the end of n years. In fact, the formula has been deduced on the premise that, by calculating the present worth of series R and principal P, both will be the same after n years.

(ii) *The capital recovery factor.* The expression

$$\left[\frac{i\,(1+i)^n}{(1+i)^n - 1}\right]$$

is called "capital recovery factor" (abbreviated to c.r.f.) and is found in tables calculated for different values of i and n. If the initial investment is multiplied by this factor, the result will be the annual equivalent value for the corresponding values of n and i.

(iii) *Present worth factor (uniform annual series).* By separating P from formula (10), then

$$P = R\left[\frac{(1+i)^n - 1}{i\,(1+i)^n}\right] \tag{11}$$

A uniform series of values R, invested at the end of each year or other period for n years or other periods is equivalent to a principal P at the beginning of the series, the value of which is given in formula (11).

The factor $\left[\dfrac{(1+i)^n - 1}{i\,(1+i)^n}\right]$

is termed the "present worth factor" (uniform annual series), and is the reciprocal of the capital recovery factor. It is sufficient to multiply the annual amount R by this factor to obtain the equivalent present worth of the series. If, for instance, it is desired to calculate all the costs of the project through the sum of equal annual expenditures equivalent to the initial investment, then the annual values of the expenditure can be converted to their present worth equivalent, using the present worth factor. Conversely, the initial investment can be converted into a uniform series of annual values to obtain total annual cost through the (c.r.f.)

When the series of annual values is not uniform, that is when the annual values are different, then formula (11) is not applicable and the present worth of annual values has to be calculated individually using formula (5), making use of the single payment present worth factor mentioned earlier.

(e) *Other deductions for formulae of equivalence*

There are 3 other methods of obtaining formulae (10) and (11). These are summarized briefly below because they may help to clarify what they represent.

(i) *To calculate the present worth of each annual amount.* The first of these methods is based on the explicit objective of discounting a series of annual values R at an initial date.

Assume that they are R1, R2, R3 ... Rn, at equal values of R, invested at the end of years 1, 2, 3 ... n.

If C1 is the discounted or present worth value of R1, and C2 of R2, etc., then at the initial date of the n years, the relationship will be as follows:

$$C1 = \frac{R1}{1+i} \text{ because } R1 = C1\,(1+i)$$

$$C2 = \frac{R2}{(1+i)^2} \text{ because } R2 = C2\,(1+i)^2$$

$$Cn = \frac{Rn}{(1+i)^n}$$

Adding the preceding equations member to member, then:

$$\sum C = \frac{R}{(1+i)}\left[1 + \frac{1}{(1+i)} + \frac{1}{(1+i)^2} + \ldots + \frac{1}{(1+i)^{n-1}}\right]$$

The first member is the sum of the present worth values, that is principal P which is sought as the equivalent of series R during n years at interest i.

In the second member it has been possible to eliminate the common factor R on the assumption that all the R amounts are the same.

The brackets enclose a geometric sum whose ratio is $\frac{1}{1+i}$. Hence,

$$P = \frac{R}{1+i}\left[\frac{\dfrac{1}{(1+i)^n} - 1}{\dfrac{1}{(1+i)} - 1}\right]$$

Making the necessary changes, this becomes:

$$P = R\,\frac{(1+i)^n - 1}{i\,(1+i)^n}$$

which is the formula already known.

The process shows that P is really the sum of the values discounted from the R amounts at different dates, that is, it shows clearly how to calculate present worth at the initial date. It can be seen that in the demonstration to obtain formula (11), the same formula was reached, by calculating present worth "forwards", that is by equalizing the principal P with all its compound interest during n years on the one hand and on the other, the series of values R with all their compound interests at the *end* of the period. In the demonstration just shown, equality at the beginning of the period of n years is verified. It is obvious that for a uniform annual series of amounts R to be really equivalent to principal P, it should be immaterial whether the present worth is calculated at the beginning or end of the period.

(ii) *Using the sinking fund factor.* The second additional demonstration included here shows the role of the sinking fund in these formulae.

If a fixed investment P is made, it has to be recovered throughout the project's useful life. Moreover, the deferred use of the resources which initially amounted to P has to be compensated. Assuming that the interest rate is i, the first problem can be dealt with (the investment recovery) through a sinking fund built up by equal annual quotas which, with their compound interest, amount at the end of the period to the value of P. In addition, throughout this period, the use of the principal P has to be remunerated at the same interest i. The sum Pi has to be paid out annually for this purpose.

For a clearer understanding of the problem, it may be imagined that a bank has lent the money P to be repaid in a lump sum at the end of n years, paying off during each of these years interest i for the total loan. To obtain the total value P which has to be paid at the end of the period, equal quotas are invested each year at the same compound interest i, so that at the end of the stipulated period the exact value of P will be obtained. The total cost to the enterprise is therefore the sum of the annual sinking fund and of the interest on all the capital.

The annual quota for the sinking fund is obtained from formula (9):

$$\frac{Pi}{(1+i)^n - 1} = a$$

The quota for annual interest payments is Pi.

The total annual quota to recover the initial capital and compensate for its use over the period is therefore:

$R = \dfrac{Pi}{(1+i)^n - 1} + Pi$, which with some changes, is equivalent to:

$$R = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] = P\ (\text{c.r.f.}).$$

The factor between brackets is the capital recovery factor, which has already been discussed.

This method of showing equivalence reveals that the same annual amounts R, calculation of whose present worth gives the principal P, can be interpreted as quotas used to form a sinking fund on the one hand, and to pay interest on capital P on the other, always providing that the sinking fund pays the same interest rate as that paid on principal P.

This interpretation is useful for tackling the problems of cumulative depreciation and of return on capital.

(iii) *Return on residual capital.* The last method of deducing the formula is related to a variant of the example given at the beginning of this annex, in which 10 000 monetary units are returned by various systems of payment. The third method considered in that example consisted in paying each year the sum of two quotas, one corresponding to interest and the other to amortization of the debt. The condition was that although the quotas might vary, their sum would be the same each year.

Suppose that the amortizations for years 1, 2, 3 etc. are termed $A_1, A_2, A_3, \ldots A_n$. R will as usual be the total annual quota, P the original principal, i the interest rate and n the number of years.

At the end of the first year it will be found that:

$$A_1 = R - Pi$$

since the amortization equals the difference between total quota R and interest quota Pi.

At the end of the second year, the capital returning interest was $(P - A_1)$, and amortization $A_2$ will be: $A_2 = R - i\ (P - A_1)$. Replacing $A_1$ by its value, then $A_2 = (R - Pi)\ (1 + i)$.

At the end of the third year, the capital earning interest was $(P - A_1 - A_2)$ and amortization $A_3$ will be: $A_3 = R - i\ (P - A_1 - A_2)$. Replacing $A_1$ and $A_2$ by their values, then $A_3 = (R - Pi)\ (1 + i)^2$.

Eventually, this gives $A_n = (R - Pi)\ (1 + i)^{n-1}$.

Adding all the equations term by term, then:

$$A_1 + A_2 + A_3 + \ldots + A_n = (R - Pi)$$
$$[1 + (1 + i) + (1 + i)^2 + \ldots + (1 + i)^{n-1}]$$

The first term is exactly P, since the sum of the amortizations ought to return the capital. Hence:

$$P = (R - Pi) \left[ \frac{(1 + i)^n - 1}{i} \right]$$

and continuing the operations, the final result is:

$$R = P \left[ \frac{i\ (1 + i)^n}{(1 + i)^n - 1} \right]$$

which again is the known formula.

This method of deducing the formula shows another interesting aspect of it. In fact, it now appears that the annuity R can be used to pay a variable and growing amortization on the initial capital and to provide a return on the residual capital at the same interest rate i, once the annual amortizations have been discounted. It has just been seen, however, that the same formula calculated R as the annual amount which was used to pay the interest rate i for the whole of capital P, and to accumulate a replacement fund.

The explanation for this apparent contradiction is found in the example given at the beginning of this annex, in which several ways of paying off a given capital were illustrated. If the depreciation reserves are invested at the same rate of interest as the capital is earning, obviously the entire capital will be earning that rate, since amortizations plus residual capital must in any one year add up to the total capital. Actually, in demonstrating the formula on the basis of the sinking fund factor it was assumed that the depreciation reserves would earn the same rate of interest as the capital used in the project itself.

Finally, amortization for any year can be found from the formula:

$$A_n = (R - Pi)\ (1 + i)^{n-1}$$

and since $(R - Pi)$ is the amortization for the first year, that is $A_1$, then

$$A_n = A_1\ (1 + i)^{n-1}$$

In other words, the amortization quota in any given year is the same as the amortization quota for the first year accumulated at compound interest until the preceding year.

## Chapter III

## CRITERIA RELATING TO THE PRODUCTIVITY OF A SINGLE RESOURCES

### I. Criteria of the private entrepreneur

#### 1. *Profitability*

(a) *Concept*

The private entrepreneur judges the merits of a project essentially in terms of the profits to be gained from it, and this is consequently the item which he hopes to increase to its maximum. On the other hand, he reduces all the resources utilized to obtain these profits to the common denominator of units of capital, the item which he is interested in lowering to the minimum consistent with the requirements of the project. The basic evaluation criterion for the private entrepreneur is, therefore, that of securing maximum profits per unit of capital employed in the project.[1] This ratio is termed the profitability of the project and is usually expressed as the percentage of employed capital represented by annual profits.

(b) *Measurement*

In spite of the clarity of the profitability concept, measurement of its coefficient lends itself to ambiguities deriving from the different ways of defining capital and profits. Thus, in analysing capital, a distinction may be made between fixed and circulating capital, on the one hand, and between equity capital and various types of credit on the other.[2] As regards profits, it has also been explained that an estimate will give different results depending on how depreciation and interest are considered.[3]

These variations lead to different profitability estimates, as may be observed from the following example.

*Example* 7. Supposing that the basic data in a given case are:

| | *Monetary units* |
|---|---|
| Fixed investment | 5 000 |
| Total circulating capital | 2 000 |
| Annual earnings | 7 000 |
| Annual costs (without depreciation) | 6 000 |
| Useful life of the fixed investment: 10 years (without residual value) | |

This combination of basic data enables various estimates of profitability to be made. Thus, annual depreciation is 500 as estimated by the linear method, and 415 when using the sinking fund method plus 4 per cent interest. This disparity leads to a variation of from 7.1 to 8.3 per cent in profitability calculated on the basis of total investments (fixed plus circulating capital), and from 10 to 11.7 per cent calculated on circulating capital. If 4 per cent interest on the fixed capital is included in the costs and calculated together with accumulated depreciation as the "equivalent annual cost of capital",[4] the profits are reduced to 385 *per annum* and the profitability estimate likewise. The different volume of credit used in financing will also produce variations. If, for instance, total circulating capital (2 000) is derived from credits at 6 per cent interest by employing the linear depreciation method, the following table will be obtained:

| | *Monetary units* |
|---|---|
| Equity capital (fixed investment) | 5 000 |
| Annual earnings | 7 000 |
| Total annual costs (including depreciation) | 6 620 |
| Annual profits | 380 |
| Profitability calculated on equity capital at 7.6 per cent | |

If total fixed investment is financed by a 10-year credit at 4 per cent interest, the servicing of this will amount to 615 *per annum* and since the capital will be returned to the creditor, depreciations should therefore be omitted from the cost of the project. In this case the position would be as follows:

| | *Monetary units* |
|---|---|
| Equity capital (circulating) | 2 000 |
| Annual earnings | 7 000 |
| Total annual costs (including servicing of the credit) | 6 615 |
| Annual profits | 385 |
| Profitability calculated on equity capital at 19.2 per cent | |

It is evident that the diverse ways of defining capital and profits in a project necessitate a careful specification as to how and on what bases the estimates have been carried out. The example also demonstrates that equity capital may produce different profitability results for the same project according to whether the latter is financed with a large amount of credit at a low rate of interest, or wholly by equity capital. The very fact that the method of financing influences profitability enables credit policy to be employed as an efficacious medium for making a given investment attractive.

For purposes of project comparison, some of the variations may be eliminated by using equivalence formulae, as explained below.

(c) *Profitability and equivalence formulae*

Profitability may be estimated by determining the rate of interest giving the financial equivalence between a series of annual values and a given amount of capital. The annual values considered here are the gross profits, i.e. the profits computed without deducting depreciation costs. They may

[1] The entrepreneur is naturally not indifferent to such aspects of the project as uncertainty regarding market conditions, hiring of an adequate labour force, credit facilities, site, technical complexities and risks in general, which he does not overlook in reaching his decision. In the final instance, however, the fundamental criterion of comparison will be profitability.

[2] See Part One, chapter V.

[3] See Part One, chapter VI.

[4] See chapter II, section I of this part.

also be called "net profits" since they are the difference between income and annual production costs. This rate of interest is termed "profitability by equivalence"[5] and its use has several advantages over the methods previously explained, since it cuts out some of the ambiguities as well as the obligation to adopt an agreed interest rate on capital in the cost estimates. Moreover, it is the only procedure enabling profitability to be calculated for the whole of the project's useful life, in spite of the possible disequilibrium between annual income and expenditure considered over the same length of time. The rate of interest thus calculated gives the total or gross profitability of the capital, and by deducting the market rate, the net profitability.

A general equivalence formula[6] has three variables: rate of interest, initial capital and its equivalent annual value. In reducing these to their common denominator, a knowledge of the rate of interest and one other variable will give the third, i.e., if the second variable is initial capital, equivalent annual value may be calculated, and if it is taken as a series of annual values, the present worth may be estimated. It is also possible to estimate the rate of interest from initial capital and a series of annual values. In algebraic terms, the interest i is expressed as a function of capital P and annual equivalent value R in the formulae already studied, but as this is a complicated mathematical operation, an approximate method by interpolation is usually substituted for it.

The general formulae should be recalled again at this juncture.

$$(1) \qquad (\text{p.w.f.}) = \frac{P}{R}; \; (\text{c.r.f.}) = \frac{R}{P}; \text{ and}$$

$$(\text{p.w.f.})\, R = P; \; (\text{c.r.f.})\, P = R$$

where (c.r.f.) is the capital recovery factor and (p.w.f.) the present worth factor—both of which exist in financial tables.

In order to calculate i when P and R are both known, the (p.w.f.) and (c.r.f.) should first be estimated and the problem will be reduced to looking up in the tables the various factor values at different rates of interest, until the nearest values—both greater and lesser—to that calculated previously by the formula are discovered. The interpolation between these two values gives i which, in turn, gives the equivalence between P and R. Either present worth or the equivalent annual value may be used indiscriminately.

*Example 8.* Assume that initial investment in a 20-year project is 10 000 and that every year annual income is 20 000 and expenditure—excluding depreciation and interest—19 000. If the difference between annual income and expenditure is called "net income", then the net return on the initial investment would in this case be 1 000 *per annum.* The problem is to calculate the rate of interest i, equating 20 years at 1 000 yearly with the original investment of 10 000. As R is equal to 1 000 and P to 10 000 in this example, the (p.w.f.) and (c.r.f.), as calculated in equation (1), are 10.0 and 0.10 respectively.

For 20 years the (p.w.f.) at 7 per cent interest equals 10 594 and, at 8 per cent interest, 9 818. By interpolation, i becomes 7.76 per cent.[7]

[5] Economists will recognize in this the well-known Keynesian concept of the "marginal efficiency of capital".

[6] See chapter II, 2, of this part and also the annex on equivalences at the end of the same chapter.

[7] The interpolation process is illustrated by the following table:

| *Rate of interest* | *(p.w.f.)* |
|---|---|
| 7 per cent ........... | 10 594 |
| 8 „ „ ........... | 9 818 |
| x „ „ ........... | 10 000 |

It can be estimated that the rate of interest giving equivalence is 7.76 per cent. The same result is obtained if the (p.w.f.) is replaced by the capital recovery factor (c.r.f.).

**Table XXXIII**

EXAMPLE 9. ARRANGEMENT OF ESTIMATES[a]

| *Rate of interest (per cent)* | *(c.r.f.) at 10 years* | *5 000 (c.r.f.) = equivalent annual cost of 5 000 monetary units fixed investment ("Calculated value" of R)* |
|---|---|---|
| 8 | 0.14903 | 745 |
| 10 | 0.16275 | 814 |
| 12 | 0.17698 | 884 |
| 15 | 0.19925 | 996 |
| 20 | 0.23582 | 1 193 |

[a] Round figures.

The process of trial and error and final interpolation is used here for factors of present worth and capital recovery, but is also valid for calculating the other variables R and P. This will be clearly seen in example 9, where the profitability equivalence is calculated on the basis of the data from example 7.

*Example 9.* According to the data in example 7, R, or net income, equals 1 000, n is 10 and P—fixed investment—equals 5 000. At different rates of interest, the (c.r.f.) values also change, and multiplied by P, or 5 000 will give various "calculated values" for R. But, as the actual value of R is 1 000, it will be necessary to find the two "calculated values" for R at the different rates of interest which most closely approximate to 1 000. An interpolation between these figures will give the equivalent interest at which the "calculated value" of R is exactly 1 000. These calculations are set out in table XXXIII.

The method consists in finding the rate of interest, according the equivalence formula, that will give the equivalent annual cost corresponding to the so-called net income. It can be seen from table XXXIII that the figure is a little more than 15 per cent.

The estimated 15 per cent rate of interest refers to initial investment only, without taking circulating capital into account, although the latter also ought to yield interest rate i. The formula would therefore be:

$$(2) \quad R = R(\text{c.r.f.}) + Ci, \; P = (R - Ci)\;(\text{p.w.f.})$$

in which C represents circulating capital (2 000 in the example). Taking the figures from the example:

$$1\,000 = 5\,000\,(\text{c.r.f.}) + 2\,000\,i$$

it would seem that 1 000 net income is sufficient to recover the fixed investment of 5 000, expressed in terms of equivalent annual costs, and to give a return on the circulating capital equal to that estimated for the equivalent annual costs.

The pertinent calculations are summarized in table XXXIV.

The rate of interest lies between 8 and 10 per cent, since the equivalent values for R (905 and 1 014) are respectively lesser and greater than the actual value of 1 000 given in the project example. Interpolation gives the exact rate as 9.7 per cent.

TABLE XXXIV

EXAMPLE 9. ARRANGEMENT OF ESTIMATES, INCLUDING CIRCULATING CAPITAL

| *Rate of interest i (Per cent)* | *(c.r.f.) at 10 years* | *5 000 (c.r.f.) or P (c.r.f.) (A)* | *2 000 i or C i (B)* | *R calculated according to equation(1) (A and B)* |
|---|---|---|---|---|
| 8 | 0.14903 | 745 | 160 | 905 |
| 10 | 0.16275 | 814 | 200 | 1 014 |
| 12 | 0.17698 | 884 | 240 | 1 124 |

(d) *Profitability calculations by the equivalence method when the series are not uniform*

The previous calculations have been simple owing to the fact that annual income and expenditure figures are assumed to be the same. When they are not the same, the equivalence formulae for uniform annual series are inapplicable and the rate of interest for equivalence is calculated by using single payment present worth factors.[8]

*Example 10.* If annual profits are not the same and circulating capital in taken into account, the method to use is that of equalizing profits with fixed capital. This may be done by estimating, at distinct rates of interest, the present worth of each of the annual values obtained from the difference between the so-called net income and interest on circulating capital. The total is then compared to the amount of initial investment, and the rate of interest at which this total equals the fixed investment is determined by successive approximations resulting from interpolation. Suppose that the data are as follows:

| | *Monetary units* |
|---|---|
| Fixed renewable investment (P) . . | 3 400 |
| Circulating capital (C) . . . . . . | 2 000 |
| Useful life (n) . . . . . . . . . | 5 years |
| Net annual income (R) . . . . . . | 1 000 in the first year |
| | 800 in the second year |
| | 900 in the third year |
| | 1 000 in the fourth year |
| | 1 100 in the fifth year |

Neither depreciation nor interest have been deducted from these profits.

[8] The formula for the separate calculation of present worth for each value is given in the annex on financial equivalences at the end of chapter II of this part.

[9] Widely spaced rates of interest have been taken in order not to complicate the table unduly. As the present worth factors (p.w.f.) used here are based on single payments, each year has to be computed separately (see the quoted annex on financial equivalences).

TABLE XXXV

EXAMPLE 10. ARRANGEMENT OF PROFITABILITY EQUIVALENCE ESTIMATES FOR DIFFERENT ANNUAL PROFITS[a]

| | *6 per cent (Ci = 120)* | | | *8 per cent (Ci = 160)* | | | *10 per cent (Ci = 200)* | | |
|---|---|---|---|---|---|---|---|---|---|
| *Year* | *(R-Ci)* | *(p.w.f.)* | *Calculated value of P* | *(R-Ci)* | *(p.w.f.)* | *(Calculated value of P* | *(R-Ci)* | *(p.w.f.)* | *Calculated value of P* |
| 1 | 880 | 0.9434 | 830 | 840 | 0.9259 | 778 | 800 | 0.9091 | 727 |
| 2 | 680 | 0.8900 | 605 | 640 | 0.8573 | 549 | 600 | 0.8264 | 496 |
| 3 | 780 | 0.8396 | 655 | 740 | 0.7938 | 687 | 700 | 0.7513 | 526 |
| 4 | 880 | 0.7921 | 697 | 840 | 0.7350 | 617 | 800 | 0.6830 | 546 |
| 5 | 980 | 0.7473 | 732 | 940 | 0.6806 | 640 | 900 | 0.6209 | 559 |
| *Total calculated value of P . .* | | | *3 519* | | | *3 171* | | | *2 854* |

[a] Round figures.

The arrangement of the calculations,[9] in which P is estimated according to formula (2) and Ci represents the interest on circulating capital, would be as shown in table XXXV.

To sum up:

| *Rate of interest (per cent)* | *Calculated value of P* |
|---|---|
| 6 | 3 519 |
| 8 | 3 171 |
| 10 | 2 854 |

The rate of interest which makes the calculated value of P equal to the fixed renewable investment, i.e., 3 400, is between 6 and 8 per cent. Interpolation fixes the rate at 6.7 in rounded decimals.

*Example 11.* Another method is to calculate the present worth of annual income and expenditure. By adding the value of the fixed renewable investment to the present worth of annual expenditure, the project's total costs may be compared with the present worth of total income. In order to discover the rate of interest giving equivalence of total expenditure and income, the trial and error and interpolation procedure must be adopted.

Circulating capital is excluded in order to simplify the calculations and the data are based on the final figures from example 4, in which an attempt is made to determine the total expenditure and income of a project (see the results in table XXXVI).

The rate of interest at which total expenditure and income balance each other is discovered by interpolation. The figures in the last column show that it must lie between 8 and 10 per cent, since somewhere between these two rates the difference between income and expenditure changes from positive to negative. Interpolation would pinpoint the rate at 9.8 per cent, which represents the net return of the fixed investment.

If it is also intended to consider circulating capital, the procedure will be similar in all respects except that the interest on such capital will be included among the cost estimates.

(e) *Profitability by the equivalence method when considering working capital and the residual value of renewable assets.*

In the preceding examples, it was assumed that fixed investment in renewable assets did not have residual value. When they are considered to have such value, known as L, the equivalence formulae are modified as follows:

(3) $R = (P - L)\ (c.r.f.) + i\ (C + L)$; or

(4) $P = (p.w.f.)\ [R - i\ (C + L)] + L$; and, in another form

TABLE XXXVI

EXAMPLE 11. PRESENT WORTH OF TOTAL EXPENDITURE AND INCOME AT DIFFERENT RATES OF INTEREST

*(Millions of monetary units)*

| *Rate of interest (per cent)* | *Total expenditure* | *Total income* | *Difference* |
|---|---|---|---|
| 6 | 101.2 | 107.2 | 6.0 |
| 8 | 90.6 | 93.1 | 2.5 |
| 10 | 81.9 | 81.6 | —0.3 |

(5) $(P—L)=(p.w.f.)\ [R—i\ (C+L)]$

Equation (3) shows that net annual income R should be sufficient to recover depreciable capital (P—L), plus the relevant interest, and to provide a return at interest rate i on working capital C and on the value of assets L, which do not depreciate.

In order to fulfil the first requisite, the capital to be recovered should be multiplied by the (c.r.f.) corresponding to the rate of interest and duration concerned, thus obtaining (P—L) (c.r.f.). For the second requirement, the capital (C+L) should simply be multiplied by i. The rate of interest for equivalence is that indicated by equation (3). This latter is nevertheless applicable only when the annual profits are the same, i.e., when R is constant, since, if it is variable, it is more convenient to use the formulae for calculating present worth. Bearing in mind that $(p.w.f.)=\frac{1}{(c.r.f.)}$ and separating P in equation (3), equations (4) and (5) are arrived at.

Formula (5) demonstrates that depreciable assets (P—L) are equal to the present worth of a series of annual values, if the volume of the latter *per annum* is given by the equation:

(6) $R—i\ (C+L)$

which represents the difference between net annual income and interest on both circulating capital C and the residual value of assets L.

To calculate profitability, the present worth as given in equation (6) is calculated at different rates of interest until, by interpolation, the particular figure is discovered which is equal to the present worth plus (P—L), or the depreciated part of the fixed assets. If the annual values of R are variable, this signifies that the calculation of present worth on residual profit must be carried out year by year, and finally added together as in example 10. The estimates also follow the arrangement of example 10, except that the values of (R—Ci) should be substituted for those of R—i (C+L) in the pertinent column.

### 2. *The rate of capital turnover*

A partial coefficient of evaluation in very frequent use is that of the so-called rate of capital turnover.[10] This coefficient is the ratio between the enterprise's gross annual production value and capital, and is an attempt to measure capital productivity, not in terms of profits but in gross production value. This coefficient is only for partial evaluation since the entrepreneur is primarily interested in maximum profits, but the capital turnover rate is nevertheless significant in that it indicates the production value that can be attained by a given amount of investment and thus indirectly reflects the possible level of profits. The reciprocal value of this coefficient is one of the quantitative measurements of a project's "capital intensity"[11]. Light industries are, on the whole, characterized by a heavy volume of direct production by investment unit, while heavy industries have a small coefficient of this type.

The rate of turnover has also been suggested as a criterion for the allocation of priorities to development projects. The following quotation reflects this point of view: "If investment funds are limited, the wise policy, in the absence of special considerations, would be to undertake first those investments having a high value of annual product relative to the investment necessary to bring them into existence".[12] This opinion has been disputed by Professor Alfred E. Kahn,[13] among others, who believes that the social differs from the private point of view and upholds the assignment of priorities to the social productivity of capital, or, in other words, to contributions to the national income.

[10] See John Happel "New Approach to Payout Calculations", *Chemical Engineering,* October 1951, p. 146.

[11] Other forms of measurement will be explained further on.

[12] Norman S. Buchanan, *International Investment and Domestic Welfare,* New York, 1954, p. 24.

[13] Alfred E. Kahn, "Investment criteria in development programmes", *The Quarterly Journal of Economics,* February 1951, p. 38. A fuller exposition of marginal social productivity will be met with further on in relation to the criterion proposed by H. B. Chenery, See section II, 5, of this chapter.

## II. Social criteria for evaluating the productivity of a single factor

### 1. *The product-capital ratio*

#### (a) *General concepts*

Just as profitability measures capital productivity in terms of special interest to the private entrepreneur, i.e., those of profits, so the ratio between capital and value added measures it in a social sense, giving what is known as the "product-capital ratio".[14]

Value added is taken to be the difference between the sales value of estimated production in the project and purchases from other enterprises to enable that production level to be reached (raw materials, energy, lubricants, spare parts, etc.), and is numerically equal to the total of salaries, wages, rent, interest and profits. Value added can be either net or gross and estimated at factor cost or market price, according to whether depreciation or indirect taxes and subsidies are excluded; if the former, value added is calculated on a net basis; if the latter, it is estimated at factor cost.

Capital estimates sometimes include the values of inventories, as they may be of particular importance in certain cases and constitute an investment in the economic as well as the financial sense. They should therefore be included in the denominator, together with the tangible depreciable assets, in order to obtain a product-capital ratio that measures an increase in the national product by the number of capital units required.

[14] The capital turnover rate is a variant of the product-capital ratio.

#### (b) *Estimate of value added*

*Example 12.* An estimate of a project's value added may be made as follows (see table XXXVII).

The layout of the table shows how value added is obtained, whether by adding net income, or deducting purchases from third parties, taxes and depreciation from gross production value.

Items VI and VII have been excluded from column (B)

TABLE XXXVII

EXAMPLE 12. DISTRIBUTION OF GROSS PRODUCTION VALUE IN ESTIMATING VALUE ADDED

| | *Gross production value* (A) | *Net income* (B) | *Purchases from third parties, taxes, depreciation* (C) |
|---|---|---|---|
| I. Salaries and wages | 40 | 40 | — |
| II. Employers' contributions to social security funds | 3 | 3 | — |
| III. Interest and rent | 5 | 5 | — |
| IV. Raw materials purchased from third parties | 30 | — | 30 |
| V. Spare parts, lubricants, electric energy and other miscellaneous purchases from third parties | 6 | — | 6 |
| VI. Indirect taxes | 2 | — | 2 |
| VII. Linear depreciation | 2 | — | 2 |
| VIII. Profits | 12 | 12 | — |
| *Total* | 100 | 60 | 40 |
| IX. Net income | — | — | 60 |
| X. Purchases from third parties and taxes | — | 40 | — |
| *Total* | 100 | 100 | 100 |

because net value added is estimated at factor cost. The gross profits (item VIII), are the profits before deduction of income tax. The computation of value added is not modified by the position of the interest, since even if it is deducted from the profits, it has to be included in value added as a direct component.

A distinction is made between the average and marginal product-capital ratios for the economy as a whole. The latter ratio is calculated by making the national product, or any of its variants, the numerator, and total renewable assets the denominator, whereas the former ratio is based on the increase in the numerator and denominator over the same length of time. Any project is marginal in relation to overall industry or economy, because it represents the total sum of investment plus value added.[15]

If the production of a project measured in terms of value added is known as P, and the capital as K, the product-capital ratio will be $\frac{P}{K}$ and wil vary according to whether P and K are estimated at social cost or market prices, whether P is net or gross and whether K includes or excludes inventories.

### (c) *Estimate of the marginal product-capital ratio*

*Example 13.* Take the case of a project for improving the production of a certain farm, in which the basic data are as shown in table XXXVIII.

On the basis of these data, the increase in production after new investment in terms added is $600 - 80 = 520$

The marginal product-capital ratio will be $0.35 = \frac{520}{1\,500}$.

For project comparisons it must be stipulated whether these figures are based on market prices or social cost.

[15] For example, in the case of specific investments improving both the quantity and quality of a farm's production the total volume of production under the new exploitation conditions cannot be considered as benefits derived from such investments. It is only the increase of production over the past volume, and its corresponding value added, that form part of the project and can be ascribed to the effects of the new investment.

TABLE XXXVIII

EXAMPLE 13. BASIC DATA

| | |
|---|---|
| I. Transfer value of the farm, including fixed assets | 1 000 |
| II. Gross value of current annual production | 100 |
| III. Value added in current annual production | 80 |
| IV. New investment as required by the project | 1 500 |
| V. Gross value of annual production after new investment | 900 |
| VI. Value added in production according to V | 600 |

### (d) *Indirect value added*

An estimate of capital productivity in terms of direct value added has no special advantages as a unique criterion of evaluation, as demonstrated by those projects producing services such as electric energy and transportation, usually of low direct value added but considerable indirect importance (see Example 14). If they are judged by the direct criterion, they would not be given priority, whereas considered indirectly, they have a high priority rating. Hence, it is important to take into account both direct and indirect effects of the product-capital ratio.

Owing to practical measurement limitations, it often happens that only the immediate effects upon a project can be taken into consideration. For instance, a manufacturing project which will produce indirect value added when its goods are at the distribution stage or are utilized by other industries must not only estimate the total value added in these activities but also the requisite additional investment for ensuring that such utilization takes place. This entails a process of project integration which is often neither simple nor feasible and the complications of which must be solved in conformity with prevailing conditions.

#### (i) *Backward effects or those relating to source*

In the case of a closed economy,[16] the gross production value of a project represents value added in the project itself plus the sum total of backward value added. Production is, in fact, the final link in a productive chain in which a series of partial values added have been connected. As purchases made by the project from other enterprises may be broken down into the respective value added and purchases from third parties, and the latter may be similarly broken down in their turn, the consequence of integrating all the backward effects is that the only components retained are values added—save in the case of purchases made abroad. Thus value added in the project, plus total backward values added, are equal to gross production value minus any direct or indirect imports forming part of the latter. This difference is usually considered as the project's contribution to the national product.[17]

In order that the product-capital ratio of the project under study should include the backward effects, it would be necessary to compute the requisite investments for establishing the chain of derived input factors. These investments will be reduced by the amount of idle capacity in the relevant items. Backward values added will be attributable to the project investments only in so far as demand derived from the project can be satisfied without new investment, that is to say, by fully utilizing idle

[16] This term denotes an economy without any foreign trade; for practical purposes, it may be considered as purely theoretical.

[17] This presupposes that the project will not employ resources utilized in other production up to that moment, as otherwise, the present and backward values added of such factors would have been generated in any case and would thus be unattributable to the project.

capacity. If, for example, a limestone quarry is producing at less than normal capacity owing to the lack of a suitable market, but a new source of demand is opened to it by the installation of an iron and steel plant, the basic investments for increased output already exist. Consequently, the new values added can be largely ascribed to the steel project's investments.

Similar observations may be made, for example in relation to agricultural properties which, without increasing their fixed investments, can expand production by means of setting up stable purchasing centres (e.g., sugar mills, refrigerating plants, dairy units, etc.). It will be necessary to carry out the same breakdown in each of these cases in order to determine whether these purchasing centres, represented by the corresponding projects, will enable existing installed agricultural capacity to be utilized or whether new investment will be required for the new production. In addition, the possible increase in capital assets necessitated by the new level of production will always have to be taken into consideration.

(ii) *Forward effects*

With regard to forward effects, it should be pointed out at once that if the project is aimed at substituting a domestically produced commodity for its imported equivalent in quantity and quality, there will be no indirect forward value added since this would be produced in any case from the imported product.

If, for want of supplies, the enterprise which will use the goods and services produced by the project as input factors has idle installed capacity, these factors can be utilized without further investment. It may be supposed, in consequence, that the increased income generated in the existing enterprise comes from project investments, with which an improved product-capital ratio has been produced. Nevertheless, higher production and income may be a tacit indication of an increase in capital stocks, which should be computed as additional investment. Whether or not these stocks constitute a substantial amount is a question to be solved according to the prevailing conditions in each case. It may also occur that the project produces for more than one enterprise and that the latter operates at different volumes of utilized capacity. Some will be obliged to expand their investments in order to utilize the extra input and some will have an expansion of stocks that is not feasible for others for, *inter alia,* geographical reasons.

The same factors are valid for value added in the distribution stage. If distribution continues to function on the basis of existing installations and fixed investment, the value added may be attributed to the project's investments. The usual result would however, be an expansion of the distributor's capital stocks. In other cases the distribution of the new commodities may require greater fixed investment (as, for instance, refrigerating plants for frozen foodstuffs) which must be included in the calculation.

The measurement of indirect effects becomes more complex and less precise in proportion to their distance from the project as the dynamic centre. This is, however, unavoidable, and the only recommendation that can be made is that the limitations of such types of estimates should be taken into account and that the latter should be calculated only in so far as they contribute in any significant degree to evaluation criteria.

In certain cases it is possible to use relatively simple methods for estimating the product-capital ratio, including

**TABLE XXXIX**

EXAMPLE 14. ELECTRIC ENERGY CONSUPTION IN CHILE

| *Sector* | *Millions of kWh* | *Percentage* |
|---|---|---|
| Household, business and government | 835 | 26 |
| Transport. . . . . . . . . . . . . . | 212 | 7 |
| Industry, mining and agriculture. . . | 2 150 | 67 |
| *Total* . . . . . . . . . . . . . . | 3 200[a] | 100 |

*Source*: Raúl Sáez, *La energía en Chile,* Santiago, 1953.
[a] Round figure.

all indirect effects, precisely because of the wide dispersion of the forward effects. Such cases are most probable in the field of electric energy production as shown in example 14.

*Example 14. Estimate of production losses attributable to a deficit in electric energy, and the necessary investments for eliminating such a deficit.*[18] In the most important region of Chile, a power deficit of 25 000 kW was recorded in 1952, together with an energy deficit of 26 million kWh. These estimates were computed by the leading company producing and distributing electricity in the region, which is responsible for 75 per cent of industrial and household requirements.[19] The energy deficit is partly absorbed by final consumers, business and public lighting, and partly by industrial, mining and agricultural production in the region. As the question under consideration is the evaluation of production losses, a preliminary estimate will show that apparently neither production nor business are affected by a deficit in final consumption of electric energy, since electricity is not indispensable for their development. Nevertheless, through consumption statistics for the region, it may be demonstrated that some part of the over-all deficit is felt in every economic sector, but, for calculation purposes, only that which has a repercussion on production is selected. Over-all consumption of electric energy in Chile[20] during 1952 is shown in table XXXIX.

As the figures in table XXXIX refer to the whole of Chile and are influenced by the consumption of large mining enterprises situated in other zones that generate their own electricity, it is assumed that for the region under discussion the distribution would be as follows (see table XL).

[18] Chilean statistics for 1952 are used in this example. The preparation of the statistics and calculations is insufficient as a basis for the assertion that the resulting evaluation represents the actual conditions of the country in that year. It is only intented to indicate a method of treatment and to point to successive calculations required for a more accurate statistical analysis.

[19] An estimate of the electricity deficit may be based on the required degree of rationing, and on the applications for connexions that have to be refused for lack of power.

[20] Consumption distribution statistics for various Latin American countries can be found in *Energy in Latin America* (E/CN.12/384/Rev.1), United Nations publication, Sales No.: 1957.II.G.2.

**TABLE XL**

EXAMPLE 14. ESTIMATED DISTRIBUTION OF ELECTRIC ENERGY CONSUMPTION IN THE DEFICIENT REGION[a]

| *Sector* | *Percentage* |
|---|---|
| Household, business and Government . . . . . . | 30 |
| Transport . . . . . . . . . . . . . . . . . . | 10 |
| Industry, mining and agriculture . . . . . . . . | 60 |
| *Total* . . . . . . . . . . . . . . . . . . | 100 |

[a] The figures should be corrected by a more accurate calculation.

To simplify, it will be assumed that the transport sector is unaffected and that the lack of electricity will be compensated by a redistribution of schedules, more intensive use of non-electrified transport, and similar measures. This table only provides approximate figures which should be analysed in greater detail.

It has been demonstrated that only 60 per cent of the electricity deficit, or some 16 million kWh, actually effects production. Taking into account the fact that private enterprises will react to the energy deficit on the public network by using their own generating plants unconnected with the general network, or by other replacement expedients, the deficit drops to 10 million kWh, a figure which also needs to be carefully checked. Thus, estimating 10 million kWh to be the final deficit with repercussions on production, a determination of the subsequent production losses may be made. The calculation of the ratio of deficit to production is explained below for purposes of illustration.

In 1952, the gross national product of Chile was 227 000 million pesos, and total electric energy consumption amounted to 3 200 million kWh, giving and average ratio of 70 pesos gross national product per kWh consumed. However, approximately 50 per cent of the gross national product is taken up by mining, agriculture and industry, and their national average ratio would be 53 pesos gross national produce per kWh. If this ratio, which is very low, is accepted for the entire region, the production loss estimated in gross value added would have been 530 million pesos in 1952. Thus, the 25 000 kW power deficit would represent, at the prices then in force, an investment of 20 000 pesos per kW, or 500 million pesos. The marginal product-capital ratio, considering the indirect effects only, would be equal to the unit, and the production loss in one year equal to the investment required to cover it.

Although the figures are only relatively valid,[21] this illustration, suffices to show the prejudicial effects of the deficit and their scope and consequently explains the priority that should be accorded to electricity projects, The direct value added in electricity production would be so small in relation to the indirect value that no effective modification would be made in the foregoing calculation.

*Example 15. Estimate of the product-capital ratio including some indirect forward effects.* In the following case the measurement of the product-capital ratio is restricted to a limited number of enterprises: project A will produce intermediate goods for enterprises B and C which do not yet exist but will be established as a result of A's operations. The example will be simplified by omitting the influence of inventories.

The characteristics of A, B and C are indicated in the respective columns of table XLI, the final column of which gives the estimates for the whole group.

The over-all capital ratio (0.37) must take into account the total values added and the over-all investments in the three projects.

Assuming now that enterprise C was already in existence but not operating for lack of domestic raw materials and foreign exchange for the imported equivalent, the figures will remain the same, except for the *new* investment which will be only 3 000 and the marginal coefficient for the whole group will be 0.73 (2 200/3 000). From this point of view, the project will be of much higher priority, since it will enable installed capacity to be utilized.

[21] One of the implicit assumptions is that the lack of electric power constitutes the only stagnation point, and that all the other input factors for a full use of installed capacity are present. The direct value added deriving from the production of the 26 million kWh would have to be included.

**Table XLI**

EXAMPLE 15. BASIC DATA

| | *A* | *B* | *C* | *Total* |
|---|---|---|---|---|
| I. Contribution to renewable assets. . . . . . | 1 000 | 2 000 | 3 000 | 6 000 |
| II. Gross annual production | 1 000 | 1 500 | 2 000 | 4 500 |
| III. Direct value added in production (II) . . . . | 300 | 700 | 1 200 | 2 200 |
| IV. Purchases from A. . . | — | 500 | 500 | 1 000 |
| V. Capital ratio (III/I) . . | 0.30 | 0.35 | 0.47 | 0.37 |

*Example 16.* Finally, an estimate of the product-capital ratio with social cost factors is given in table XLII, based on a project with the following investment data.[22]

It is assumed that the social cost of these investments was estimated in conformity with the particular circumstances of each item, as follows: I. There is neither over- nor under-estimation of the exchange used. The item remains the same. II. Suppressed. III. It is accepted that persons in "disguised" occupations are employed. The opportunity cost of the working force will be 80 per cent of market value. IV. The item is unchanged. It also includes engineers, administrators, etc. V. As the indirect taxes concerned are included in item VI the item remains the same. VI. Suppressed in order to compute the social cost. VII. Financial investment only is concerned. The opportunity cost of the land has been placed at zero as it has no alternative use. VIII. The social cost of the investment is 80 per cent, in comparison with the market price for it which is 100.

Assume now that the production costs for the enterprise are as shown in table XLIII.

[22] In order to simplify the estimates, investments in inventories have not been taken into account.

**Table XLII**

EXAMPLE 16. INVESTMENTS

| | *Market price* | *Social cost* |
|---|---|---|
| I. Imported machinery (excluding customs duties) . . . . . . . . . | 20 | 20 |
| II. Customs duties. . . . . . . . . . | 7 | — |
| III. Unskilled labour. . . . . . . . . | 25 | 20 |
| IV. Skilled labour. . . . . . . . . . | 10 | 10 |
| V. Various national materials and equipment. . . . . . . . . . . . . | 30 | 30 |
| VI. Indirect taxes on materials. . . . . | 4 | — |
| VII. Land. . . . . . . . . . . . . . . | 4 | — |
| VIII. *Total investments*. . . . . . . . . | *100* | *80* |

**Table XLIII**

EXAMPLE 16. COSTOS

| | *Annual production costs* | | *Net annual value added* |
|---|---|---|---|
| | *Market prices* | *Social cost* | |
| Salaries and wages. . . . . . | 25 | 25 | 25 |
| Profits . . . . . . . . . . . | 20 | 20 | 20 |
| Rent and interest. . . . . . . | 10 | 10 | 10 |
| Depreciation (linear—10 years) | 5 | 4 | — |
| Purchases from third parties . . | 45 | 45 | — |
| Indirect taxes. . . . . . . . | 5 | — | — |
| *Total* . . . . . . . . . . . . | *110* | *104* | *55* |

In order not to complicate the example, it is assumed that the only difference between pricing at market values and at social cost will derive from indirect taxes paid on "purchases from third parties", as these taxes are omitted from the social cost estimates. As regards manpower, it is admitted that there will be no appreciable difference between opportunity and market costs—taking into account the whole of the project's useful life. The net value added is 55 *per annum*, and the product-capital ratio can be measured according to either social or market costs, being 0.69 in the first case and 0.55 in the second.

### 2. *Capital intensity*

#### (a) *Concept and measurement*

The concept of capital intensity concerns the greater or lesser use to which capital is put in the projects. The various quantitative expressions of this can be divided into two major groups. The first is composed of those coefficients representing the reciprocal value of different capital productivity coefficients, as explained in the preceding pages; according to this form of measurement, capital intensity will be the total capital required by the project per unit of value added or gross annual value produced. The ratio of total capital and gross annual production value is the reciprocal value from which the capital turnover rate is measured, and the ratio of total capital to annual value added is the reciprocal value of the product-capital ratio and is known as the "capital coefficient". The second group of coefficients used to express the concept of capital intensity comprises those which measure the input of capital, i.e., depreciation per unit of value added or of gross production, usually in percentage form.

#### (b) *Capital intensity estimate*

*Example 17.* If it is intended to measure capital intensity on the basis of example 16, employing the methods indicated and estimating cost at market prices, the results would be as given in table XLIV.

The measurement which takes into account annual capital input per unit of production is more significant. For instance, in the case of two projects with identical characteristics, except that the lifespan of one is 20 years and of the other 10 and data corresponding to example 16, coefficients I and II will be equal in both, whereas there will be variations between the single and double coefficients in III and IV (see again table XLIV). It is obvious that the latter are more representative of the capital intensity required in both cases.

**Table XLIV**

EXAMPLE 17. CAPITAL INTENSITY MEASUREMENT USING DATA IN EXAMPLE 16[a]

| *Measurement method* | *Coefficient of capital intensity for various depreciation periods* | |
|---|---|---|
| | *20 years* | *10 years* |
| I. Investment per unit of annual net value added (100 divided by 55) . . . . . | 1.82 | 1.82 |
| II. Investment per unit of gross annual production (100 divided by 110) . . . | 0.91 | 0.91 |
| III. Linear depreciation per unit of annual value added—percentage (100 5/55 and 100 10/55) . . . . . . . . . . . . . . | 9.10 | 18.20 |
| IV. Linear depreciation per unit of gross production value—percentage (100 5/110 and 100 10/110) . . . . . . . . . . . | 4.55 | 9.10 |

[a] See tables XLII and XLIII.

The measurement of capital intensity frequently considers interest together with depreciation, utilizing for this purpose one of the formulae already described. Again on the basis of the data from example 16, and referring back to table 39, fixed investment at market prices will be 100, and the equivalent annual cost of capital—including depreciation over 20 years and 10 per cent interest—will be 10.25 by the approximation method[23] and 11.75 by the exact method.[24]

Supposing that an estimate of capital intensity includes the former figure of 10.25, the total annual cost of capital per unit of value added will be $\frac{10.25}{55}$ or by unit of gross production value $\frac{10.25}{110}$. The corresponding percentages will be 18.6 and 9.3 respectively.

### 3. *Employment per unit of capital*

#### (a) *Definition*

It will always be important to make some provision in the project for the impact which it may have on the question of employment. If special unemployment problems exist, the number of personnel employed per unit of capital may become a preponderant coefficient.

This employment coefficient—as it may be termed—will be obtained by dividing the number of persons employed in the project by the latter's total capital requirements.[25] The social pricing of invested capital will be especially important here because, if unemployment exists, the denominator will be reduced without affecting the numerator, thereby improving the coefficient. Pricing at market prices will be, as always, essential when taking up the problem of financing. According to this criterion, those projects employing the greatest number per unit of capital at social cost will have higher priority than those valuing capital at market prices.

It should be recalled here that projects need different types of manpower, that the labour force available in underdeveloped countries is usually unskilled and that, as such it cannot be used to occupy all the posts created under the project. Hence a computation of the employment coefficient of unskilled labour per unit of capital would be useful.

#### (b) *Indirect effects*[26]

Employment of personnel in a specific sector—for example public works—will help to create new work sources.

[23] Linear depreciation (5.00) plus average annual interest (5.25). This interest would be included in the item for "Rent and interest" in table XLIII.

[24] Recovery factor 0.11746 in the equivalence formula described previously.

[25] The reciprocal, or amount of capital per employed person, is termed "capital density".

[26] These secondary effects were formally analysed for the first time by R. F. Kahn when he presented his theory of the employment multiplier (R. F. Kahn, "The relation of home investment to unemployment", *Economic Journal,* June 1939). This theory was later amplified to deal with the income multiplier and is an important factor in Keynesian and post-Keynesian theories.

Such indirect effects may be very important in the case of general unemployment, and it would therefore be advisable to estimate them, in spite of the practical and conceptual difficulties entailed by this.

Input-product studies enable a quantitative estimate to be made of direct and indirect employment of labour as a prerequisite for increasing production in any given sector. For instance, on the basis of the structural characteristics of the United States economy in 1939, it was possible to work out ratios between the final purchase of various goods and services and the total employment figure. In accordance with these ratios, an addition of 1 million dollars to the final purchases of foodstuffs and agricultural products while only raising employment in the relevant sector by 729 persons would increase over-all national employment by 1 139 persons.[27] An equal increase in expenditure on transport services would rise in that sector by 243 persons but would increase over-all employment by 489 persons. These figures emphasize the difference between direct and over-all effects upon employment. Table XLV shows the results of the survey carried out in the United States.

In the absence of studies such as that referred to, an attempt may be made to measure the forward and backward effects that are nearest to the project. If employment per unit of capital is measured and derived employment is recognized as an indirect benefit, the investment required for such derived employment must be estimated. If, in the derived activities, some idle installed capacity remains, no new investment will take place and the whole of the extra employment may be attributed to the project.

The evaluation criterion in employment terms is used to show a partial aspect of the project which, under certain circumstances, may have some special importance, but which only under exceptional conditions could be adopted for the establishment of a definitive order of priority.

[27] In round figures.

**Table XLV**

UNITED STATES: TOTAL AND DIRECT EMPLOYMENT COEFFICIENTS FOR VARIOUS BRANCHES OF PRODUCTION, BY UNIT OF FINAL DEMAND, 1939

*(Thousands of persons for each million dollars of final demand)*[a]

| | Employment coefficient | |
|---|---|---|
| | Total | Direct |
| Agriculture and foodstuffs | 1.1393 | 0.7239 |
| Minerals | 0.5659 | 0.1595 |
| Metals | 0.5057 | 0.2461 |
| Fuel and power | 0.5176 | 0 1775 |
| Textiles and leather | 0.7701 | 0.3563 |
| Railway transport | 0.4886 | 0.2429 |
| Foreign trade (imports) | 0.7657 | — |
| Industries, unclassified | 0.6120 | 0.2029 |
| Government (taxes) | 0.4076 | 0.0739 |
| All other industries | 0.5394 | 0.4125 |

*Source*: W. W. Leontief, "Output, employment, consumption and investment". *The Quarterly Journal of Economics*, Vol. LVIII, No. 2 (February 1944), p. 312.

[a] That part of production purchased for final use, i.e., which will not undergo any transformation process. Total production in the corresponding sector is usually greater, because it also includes intermediate demand, consumed by other sectors to produce final goods.

## 4. *Labour productivity*

### (a) *Basic concepts*

Labour productivity can be defined as production value obtained per person employed.[28]

Production is usually expressed in terms of the gross sales value of its goods and services, but for project comparison it will usually be more helpful to express it in terms of value added.[29] The labour force can either be expressed in physical terms of man/years and man/hours, or as monetary units equivalent to the cost of employed manpower,[30] although the introduction of monetary units will raise the problem of pricing, which has already been discussed.

In evaluating a given project, the labour productivity concept adopted in this section of importance for comparing alternative production techniques based on the substitution of labour for capital.[31] In such a comparison, the social pricing of the factors may have a decisive part to play. Once the most suitable technique has been decided upon, the project's labour productivity—in terms of value added—will represent its contribution to the level of average *per capita* income. It will also serve as a partial evaluation coefficient for the comparison of projects producing different goods and services. Such a comparison will, nevertheless, have its limitations because, although the fundamental objective of economic development is to raise the *per capita* rate of growth of the national product, it does not necessarily follow that projects showing greater labour productivity have priority; other resources are also employed in production and the higher rate shown may merely be a result of the substitution of labour for capital, as pointed out previously.

### (b) *Evaluation of technical alternatives*

The decision on what labour intensity should be employed in a project depends not only on the pertinent technical background data,[32] but also on the economic considerations connected with the relative availability of capital resources and labour, i.e., their respective prices.

In order to compare capital intensity with labour in-

[28] It has already been pointed out that this meaning differs from that normally assigned in economic theory to signify the contribution of a resource (in this case, manpower) to production, in other words, that part of production which is directly attributable to each contributing unit.

[29] If one type of commodity, or various types that may be reduced to a common physical unit, are produced, physical units may also be used to express production (so many tons of pig iron per man/year, for example).

[30] The use of the man/year unit or its equivalent value in monetary units does not throw light on the number of hours worked per year, and, when comparing projects with disparate work regimes, may lead to errors of appraisal. These may be particularly serious in the case of agricultural and non-agricultural projects.

[31] Some aspects have been indirectly or partially dealt with in the discussions on opportunity cost of labour, employment per unit of capital—or its reciprocal, capital density—and the ratio between productivity and evaluation concepts.

[32] It is self-evident that the possibility of substituting labour for capital is largely dependent on the technical nature of the process for which the above-mentioned techniques will be used and whether the phase concerned is that of construction or operation. On the whole, a greater physical possibility of substitution exist in activities such as the loading, unloading and shipment of materials, i.e., in projects, whose construction involves road or dam building. Inversely, in the case of processes requiring the operation of, for example, an oil refinery, these substitution possibilities are much less

Table XLVI

EXAMPLE 18. BASIC DATA ON A PROJECT WITH TWO TECHNICAL ALTERNATIVES

*(Millions of monetary units)*

| | *Alternative A* | | *Alternative B* | |
|---|---|---|---|---|
| I. Renewable fixed investment | 100 | | 200 | |
| II. Useful life (depreciation and obsolescence, in years) | 20 | | 20 | |
| III. Interest rate (percentage) | 8 | | 8 | |
| IV. Employment (number of persons) | 1 000 | | 600 | |
| V. Average cost per man/year including social security contributions | 0.030 | | 0.033 | |
| | *Cost structure* | | | |
| | *Alternative A* | | *Alternative B* | |
| | *Total value* | *Value added* | *Total value* | *Value added* |
| VI. Labour | 30.0 | 30.0 | 20.0 | 20.0 |
| VII. Capital | | | | |
| (*a*) Linear depreciation | 5.0 | — | 10.0 | — |
| (*b*) Interest (annual average) | 4.2 | 4.2 | 8.4 | 8.4 |
| VIII. Other costs[a] | 46.0 | 6.0[b] | 46.0 | 6.0[b] |
| IX. Profits | 14.8 | 14.8 | 15.6 | 15.6 |
| *Total* | 100.0 | 55.0 | 100.0 | 50.0 |

[a] For the sake of simplicity, it is assumed that the variations in capital intensity will not influence "other costs"; in practice, this is most unlikely since, for example, there would be changes in electric energy consumption.
[b] It is assumed that the value added is derived from rent and other interest.

tensity in a project, both coefficients must be represented in homogeneous terms, which entails the measurement of labour productivity in monetary values.

Labour intensity will be the reciprocal value of labour productivity. Its measurement and comparison with capital intensity can be undertaken as follows (see example 18).

*Example 18.* It is supposed that the cost structure of a project for alternatives A and B is as indicated in table XLVI.

In the case of example 18, labour productivity can be expressed as follows (see table XLVII).

It must be pointed out that coefficient I for measuring gross production value per person is of doubtful validity for comparing projects producing different goods and services, since it would be sufficient, for example, for processed raw materials to be of high unit value for the coefficient to rise. It is really only useful in the case of a comparison of alternative techniques for the production of one type of commodity and cannot assist in a question of choice between producing commodity A or commodity B.

The net value added in annual production per person (coefficient II) has more significance in that it expresses the project's merits in terms of the net national product, and may also be utilized as a coefficient of partial evaluation in comparing heterogeneous projects.

As coefficients III and IV reflect the same as coefficients I and II, except that labour input is expressed in monetary terms, the valuation of the labour force in monetary units may be a highly important factor. Projects that are intended to achieve the same physical production by means of identical processes and equal labour productivity expressed in terms of physical units of production per man/hour, but located in unequally development regions, may have quite different productivity expressed in monetary units. In fact, labour will have a lower value in less developed regions and, consequently, if production value in monetary terms is the same,[33] its value will be greater per unit of labour input.

Labour intensity, which is represented by the reciprocal value of the preceding figures, is given for alternatives A and B in table XLVIII.

The coefficients given in the foregoing tables show that the rise of 67 per cent in labour productivity, expressed as gross production value (coefficient I, table XLVII) is concomitant with capital productivity being reduced by half. (As revealed by the item for capital in table 34, 18.4 million monetary units are required instead of 9.2 million for the same production.) Capital productivity in terms of value added, i.e., the net products/capital ratio, drops to 0.55 in alternative A and 0.25 in B, that is, to less than half.

The greater capitalization effort is hardly recompensed by a reduction in costs since these show no more than a slight decrease, from 85.2 to 84.4 million monetary units, and even this small advantage may disappear if social costs replace market prices. Supposing that, in accordance with this form of pricing, the rate of interest will be 12 per cent and the social cost of labour is 70 per cent of the market price, the costs will be 78.3 million in alternative A and 82.6 million in B. Project A is thus clearly advantageous (see table XLIX).

Finally, the composition of value added in both alternatives should be noted. In alternative A, labour cost is 54.5 per cent of value added, whereas in B it is only 40 per cent. The figures in the example show that a project comparison based on the global amount of value added

[33] Depending for example, on whether production is destined for either home consumption or export. In the former case, commodity prices may also be lower.

Table XLVII

EXAMPLE 18. COEFFICIENTS FOR MEASURING LABOUR PRODUCTIVITY

*(Monetary units)*

| *Coefficient* | *Alternative A* | *Alternative B* |
|---|---|---|
| I. Gross value of annual production per person | 100 000 | 166 600 |
| II. Net value added of annual production per person | 55 000 | 83 300 |
| III. Gross production value per unit of labour cost | 3.3 | 5.0 |
| IV. Value added to production per unit of value added by labour | 1.83 | 2.50 |

Table XLVIII

EXAMPLE 18. COEFFICIENTS FOR MEASURING LABOUR INTENSITY[a]

| *Coefficient* | *Alternative A* | *Alternative B* |
|---|---|---|
| I. Man/years per million monetary units of gross production | 10 | 6 |
| II. Man/years per million monetary units of value added | 18 | 12 |
| III. Percentage of labour cost in gross production value | 30 | 20 |
| IV. Percentage of value added by labour within total value added | 54.5 | 40.0 |

[a] Round figures.

**Table XLIX**

EXAMPLE 18. ANNUAL COST STRUCTURE WITH SOCIAL PRICING

*(Millions of monetary units)*

| | *Alternative A* | *Alternative B* |
|---|---|---|
| Labour | 21.0 | 14.0 |
| Capital: | | |
| Linear depreciation | 5.0 | 10.0 |
| Interest (annual average) | 6.3 | 12.6 |
| Other costs | 46.0 | 46.0 |
| *Total costs* | *78.3* | *82.6* |
| Costs at market prices according to table 34 | 85.2 | 84.4 |

throws no light on how this value added is distributed in each case. Such differences in income distribution result in variable repercussions upon demand, savings formation and other important economic processes which form part of the secondary effects of the project.

(c) *Technical efficiency*

In many cases it will be possible to raise labour productivity by taking advantage of techniques which do not necessarily involve increased capital intensity. Such techniques range from greater skill among the workers to improved organization of the enterprise. In agriculture, the use of selected seeds, knowledge of the best periods for sowing correct spacing and depth or simply good crop care, may considerably augment production without any need for large capital investment. It must be remembered, in this respect, that the engineering study should include an estimate of the technical level that may be attained, considering this level as part of the background data and not as variable. On the other hand, capital intensity can be a variable presenting alternatives such as those presented in example 18.

### 5. *Marginal social productivity of capital and its contribution to national income*

(a) *Approach*

An article by H. B. Chenery[34] puts forward an evaluation criterion that measures capital productivity in terms of its contribution to national income. It is characterized by its method of defining and estimating the project's contribution and by its inclusion of the results of over- or under-valuation of the exchange rate. In the following pages this article has been summarized and commented upon in order to facilitate an understanding of it and to relate the above-mentioned criterion to other concepts and definitions dealt with in previous pages.

According to Chenery, no system of priorities can be evolved unless certain fundamental facts are kept in mind. In the first place, it should be taken into account that in under-developed countries private costs and benefits may be completely different from social costs and benefits. This is the problem that has been discussed in the *Manual* under the heading of social pricing and forward and backward effects. In order to assist Government in formulating their investment policy, social productivity needs to be measured; this involves a practical method for estimating the social marginal product, and the drawing up to a frame of reference for divisions based on these measurements.

In the second place, the author believes that when priorities are based on the investment's effects upon partial economic aspects—such as profits or foreign exchange availabilities, which are most commonly considered—this presupposes that all other factors are equal.

In the absence of such conditions, priority criteria that take only one effect into consideration may lead to totally erroneous conclusions.

As projects actually have more widespread effects, including among others, the redistribution of the national income, it would, strictly speaking, be necessary to measure each one by finding their common denominator. The author adopts as his denominator the national income factor; owing to practical limitations, he has included in it only the effects of increased production, and those related to foreign exchange availabilities given certain over- or under-valuation of the exchange rate.

The author recommends the elimination of subsidies, tariffs and indirect taxes; he also urges the employment of opportunity costs when advisable and the inclusion of external economies[35] in computing production.

(b) *Formulae*

The following formula includes all the foregoing elements:

$$(7) \qquad SMP = \frac{X + E - Mi}{K} - \frac{L + Md + O}{K} - \frac{r}{k}\,(aB_1 - B_2)$$

SMP being the "social marginal productivity" defined by the author as checked "average annual increment in national income" plus "balance-of-payments" equivalent. The former will be measured by the two first terms of the second part of the equation, and the balance-of-payments equivalent by the third term.

[34] H. B. Chenery, "The application of investment criteria", *The Quarterly Journal of Economic,* vol. LXVII, No. 1, February 1953, pp. 76-96.

[35] The expression "external economy", employed by Marshall and other authors after him, is often used ambiguously. One of the definitions of this, suggested by Everet E. Hagen in the *Handbook for Industry Studies,* published by the Centre for International Studies (Massachussetts Institute of Technology), is as follows: "a reduction in a production cost for a given firm or industry resulting from the establishment or growth in size of some other firm or industry".

He also warns readers that there will be no unanimous acceptance of his definition by economists.

A fuller and more up-to-date commentary on this subject is given in an article by Marcos Fleming entitled *"As economias, external e as doutrinas do desenvolvimento equilibrado", Revista Brasileira de Economía,* June 1955, which discusses the implicit basis of modern variants on the doctrine of balance development. According to Fleming, this assumes that the introduction of cheaper production methods leading to increased output in a given industry A would augment the profitability of other industries XX, although the production of A itself is not profitable and although XX have no particular connexion with A either as buyers or suppliers. It is also supposed that, if the industries XX are operating inefficiently, the expansion of A will promote economies conducive to a rise in XX's production. The author especially calls attention to the dangers of overestimating the virtues of these external economies when there is little supply-elasticity and comments upon the various definitions of the term "external economies" in a special footnote.

According to Chenery's formula, the external economies include what have been called in this *Manual* the "forward effects" of the project.

Prior to clarifying the symbols in this formula, it would be opportune to explain why the balance-of-payments equivalent is added in national income units. This is necessary since, if the exchange rate stands at par, the effects of the project upon the balance of payments will be automatically included in the estimates of production value and costs. If, for example, a certain project has a favourable effect on the balance-of-payment surplus to the extent of 100 dollars yearly, and the official exchange rate is 200 monetary units to the dollar, the effect will amount to 20 000 monetary units (200 × 100 dollars) which cannot be considered as an extra contribution to national production when the exchange rate is at par, because this would imply duplication.

When there is either over-valuation or under-valuation of the exchange rate, the situation changes. Assuming that the exchange rate is over-valued and its true level should be 300 instead of 200 units to the dollar, and that the dollar items in the project's budget of income and expenditure are calculated at 300 units, this would signify an under-valuation of both income and costs by 100 units per dollar. Consequently, as the project's balance of payments shows a surplus of 100 dollars *per annum,* its net profits are also underestimated by 10 000 monetary units yearly (a difference of 100 dollars × 100 monetary units between the real and over-valued exchange rates). Accordingly, despite the fact that the current value of the dollar is 200 monetary units, its social pricing at 300 would cause the difference between total income and expenditure to exceed the calculation at market prices by 10 000 monetary units.

The third term in Chenery's formula (7) is employed to measure the effects of possible over-valuation or under-valuation of the exchange rate. As may be realized, this is a question of how to include the social pricing of foreign exchange in the computations. If, for instance, all foreign exchange items are calculated at their social cost (real or parity exchange rates), the aforesaid third term need not be included in the equation, but if the items are computed at non-parity current rates of exchange, the requisite adjustment must be made. The advantage of correcting under- or over-valuation separately, instead of by pricing at parity, lies in the fact that its influence on final project comparison and the total coefficient can also be appointed separately.

The meaning of the equation symbols is as follows:

K = capital increment (investment);

X = the increase in annual production value originated by the project, at market prices, after excluding tariffs, taxes and subsidies;

E = value added to production due to external economies;

Mi = the cost of imported materials;

L = labour cost;

Md = the cost of domestic materials;

O = fixed costs, including administration costs and depreciation;

r = units of national income equivalent to an improvement of one unit in the balance of payments owing to over- or under-valuation of the exchange rates. Arithmetically, r is obtained by subtracting the official from the real rate of exchange and dividing the difference by the official rate. Hence when there is equilibrium in the balance of payments, and r = 1 when the real rate of exchange is double that of the official.

a = combines rate of amortization and interest on foreign loans, hitherto known as the capital recovery factor (c.r.f.);

$B_1$ = effect of the project's installation costs on the balance of payments (that part of the investment which is carried out in foreign currency);

$B_2$ = the effects of the project's operation upon the balance of payments (foreign exchange receipts and expenditure in the installation and operation of the project).

Formula (7) may also be expressed thus:

$$\text{SMP} = \frac{V}{K} - \frac{C}{K} + \frac{Br}{K} \text{ in which} \tag{8}$$

$$V = X + E - Mi \tag{9}$$

$$C = L + Md - O \tag{10}$$

$$B = aB_1 + B_2 \tag{11}$$

In equations (8) to (11), the explanation of the terms is as follows:

V = gross production value of the project, modified by subsidies, taxes and external economies, and from which imported input factors have been deducted;

C = total costs of national factors;

B = total net effect on the balance of payments;

$\frac{V}{K}$ = defined by the author as "value added in the domestic economy" per investment unit (rate of turnover);[36]

$\frac{C}{K}$ = operating cost per investment unit, excluding imported materials;

$\frac{Br}{K}$ = premium per investment unit due to the effect of over- or under-valuation of the balance of payments, expressed as explained previously in national income units.

Finally, equation (8) may be presented in this way:

$$\text{SMP} = \frac{V}{K} \cdot \frac{V - C}{V} + \frac{Br}{L} \tag{12}$$

According to this, social marginal productivity is the addition of two terms: (i) the result of multiplying capital productivity by the ratio of profits to value added in production (each term defined as above); and (ii) the balance-of-payments premium. This equation demonstrates that low capital productivity $\frac{V}{K}$ in a given project can be offset by a high value $\frac{V-C}{V}$ if the effect on the balance of payments remains constant.

### (c) *Application to specific cases*

*Example 19.* Chenery gives several examples with approximate figures for industrial projects in Greece and

[36] This definition does not coincide exactly with, what has been termed the "capital turnover rate" in the *Manual,* nor with the "products-capital ratio". V represents the project's total production value, socially priced and including external economies but excluding imported materials. It should be taken as the total domestic value added in the project, plus the total backward domestic values added.

**Table L**

EXAMPLE 19. SOCIAL MARGINAL PRODUCTIVITY OF INDUSTRIAL PROJECTS IN GREECE

| | *Nitrogenous fertilizer* | *Cement* | *Phosphate fertilizer* | *Sulphuric acid* | *Soda* |
|---|---|---|---|---|---|
| I. Investment K (thousands of dollars) . . . . . . . . . . . . . . | 17 000 | 6 750 | 2 450 | 1 450 | 3 500 |
| II. Capital turnover $\frac{V}{K}$ . . . . . . . . | 0.67 | 0.93 | 0.74 | 0.52 | 0.41 |
| III. Cost ratio $\frac{C}{K}$. . . . . . . . . . . . | −0.29 | −0.37 | −0.37 | −0.11 | −0.27 |
| IV. Balance-of-payments $\frac{Br}{K}$[a] . . . . . | 0.35 | 0.07 | 0.07 | 0 | 0.09 |
| V. Value margin $\frac{V\text{-}C}{V}$ . . . . . . . . | 0.56 | 0.60 | 0.49 | 0.79 | 0.34 |
| VI. SMP[b]. . . . . . . . . . . . . . . | 0.73 | 0.63 | 0.44 | 0.41 | 0.23 |

*Source*: H. B. Chenery, *loc. cit.*, p. 84 (simplified).
[a] Excluding overhead costs.
[b] SMP = II + III + IV = II × V + IV.

agricultural projects in the south of Italy, one of which is reproduced here for purposes of illustration (see table L).

Table L shows that the utilization of partial coefficients instead of a global coefficient will not give the same priority ranking. Thus, according to coefficient $\frac{V}{K}$, the cement industry would have the highest priority while, if the balance-of-payments effect were taken as the conclusive factor, nitrogenous fertilizers would rank higher, or sulphuric acid if the profits-sales ratio were adjusted. The combined effects would, however, give nitrogenous fertilizers a favourable priority margin.

(d) *Effects on the balance of payments*

As explained previously, a measurement of the influence of over- or under-valuation of the exchange rate depends upon a prior calculation of the project's net effect upon the balance of payments. This is then multiplied by the corrective factor r.

The author pays special attention to the problem of measuring direct and indirect effects upon the balance of payments by equations in which the parameters represent the propensity to import and to consume the income multiplier and the direct and indirect import requirements per production unit of the commodity in question. He also includes in his formulae the effects of inflationary financing on the balance of payments. An outline of the ideas concerning balance-of-payments effects will be included when the subject of evaluation in terms of foreign exchange is dealt with.[37]

[37] It has been preferred to deal with this subject separately because the computation of the net balance-of-payments effect, taking into account the direct and indirect repercussions of a project, is an accessory to the evaluation criterion itself. In this respect, the real focal point of this criterion is the parameter r, which, as already explained, measures the effects of over- or under-valuation. Conversely, the concept of direct and indirect effects on the balance of payments requires certain prior explanation which will form part of the discussions on the corresponding evaluation criteria.

(e) *Comment*

Formula (7) may also be expressed as the following equation:

$$(13)\ \text{SMP} = \frac{X - (Mi + L + Md + O)}{K} + \frac{E}{K} + \frac{Br}{K}$$

The numerator of the first term of the equation's second member represents profits in their conventional sense, i.e., production value minus production costs, corrected by taxes and subsidies and by the possible use of labour opportunity cost. The second and third terms represent the corrective effects of external economies and exchange rates, the first correction corresponding broadly to what the *Manual* has called indirect effects. Corrections based on the exchange rates employed correspond, as pointed out, to the concept of social pricing.

The characteristics of the criterion in question are therefore that (i) it has been suggested for integral project evaluation; (ii) it is based on the measurement of capital productivity rather than of the input complex; and (iii) it expresses the benefits of the project in terms of profits and total effects, socially priced by means of the inclusion of external economies, the omission of subsidies and taxes and the use of parity exchange rates and the opportunity cost coefficient.

Apart from any theoretical discussion that may be provoked by the Chenery criterion,[38] objections have been made to the difficulty of measuring the parameters and coefficients in his equations and the inaccuracy of the rough estimates represented by these parameters, although these are unavoidable drawbacks in under-developed countries.[39]

With regard to the practical difficulties of measurements, the author affirms that "the margin of error involved in calculations of this sort in under-developed countries may lead some readers to doubt the usefulness of the whole operation. In my opinion, however, the obstacles to the achievement of desirable results through free market forces

[38] Some of these criticisms will be brought up later when the criterion proposed by Jorge Ahumada is discussed.

[39] Annibal Villela, *"Criterio de Seleção de Investimentos", Economica Brasileira*, vol. 1, No. 3, July-September 1955, p. 170.

are so great that they greatly reduce the social value of investment unless an attempt is made to offset them. The method used here is largely an effort to make such corrections for the difference between private and social profitability."

### 6. *The foreign exchange factor*

#### (a) *Positive and negative effects of a project on the balance of payments*

A project may be a net consumer or producer of foreign exchange depending on whether the final balance of payments shows a debit or credit balance for foreign exchange earned or freed by import substitution or export expansion.

It has been decided to simplify the exposition by terming "positive foreign exchange effect" the amount of foreign currency freed by import substitution or increased exports. This refers to total import substitution or export increment without discounting the foreign exchange that may be used to achieve these objectives.[40] The negative effect will be represented by the quantity of foreign exchange required for installing, operating and maintaining the project, and the net effect will be the difference between the negative and positive effects.

#### (b) *Direct and indirect effects*

The direct effects of the project upon the balance of payments derive from foreign exchange transactions based on the purchase or sale of goods and services directly connected with the project. The indirect effects arise from the remaining foreign exchange transactions and may be either backward or forward.

In the case of a steel industry project founded on two basic domestic raw materials, coal and iron ore, a calculation of direct effects on the balance of payments would take into account the positive results of possible import substitution and the negative effects of first, the installation of the industry and, second, the purchase of materials or services abroad during its operation.

An examination of the indirect effects must not omit possible additional investment required to satisfy increased demand for coal for the new iron and steel plant. Such investment will probably include a foreign exchange component; the coal mining itself may also lead to foreign currency spending. Moreover increased domestic coal consumption caused by the new enterprise may perhaps lower export earnings, if the coal now retained within the country was previously sent abroad. Similarly, if iron ore was previously exported, such exports will likewise decline, and this reduction has to be included among the indirect negative effects. A similar line of reasoning may be pursued for imported input factors and the whole chain of effects followed to its origin.

The actual commodities produced may also have indirect effects on the balance of payments. For instance, the distribution and transport services for substituted goods may require foreign exchange expenditure over and above that for the imported product, and the same may be said of exportable goods.

It is clear that the algebraic total of direct effects, as far as foreign exchange is concerned, does not represent the project's true final effect on the balance of payments, and, for this reason, it would be advisable to analyse the indirect effects in order to avoid approximations that are too wide of the mark. A few simple estimates, tracing back the project one or two steps, will give an adequate approximation in most cases.

Although an examination of the foreign exchange situation from the point of view of input factors will, of necessity, add to the negative effect, utilization of the project's commodities will not automatically increase the positive effect. Foreign exchange savings built up by import substitution may equally well be formed by importing as before. For example, a steel transforming industry using the products of a national steel plant may operate with imported input factors. The positive effect ends with the substitution of raw materials which will, in future, be supplied by the steel enterprise.

Nevertheless, the opinion is frequently expressed that a national industry, by producing specific semi-finished products, encourages the development of derived industry, and hence additional foreign exchange savings. Although, strictly speaking, derived industry may also expand on the basis if imported raw materials, particularly in the initial stages what actually happens is that the installation of the matrix industry may stimulate the establishment of peripheral industries.

Owing to the restricted scope of the balance of payments, future access to imported raw materials is uncertain and many activities which would thrive on ready access to basic raw materials are inhibited.

In the case of a representative industry, such as iron and steel, experience has shown that its establishment is accompanied by a parallel development in the metal transforming industry, the conclusive expansion factor being the certainty of raw materials supplies. Nevertheless, in formal estimates, a recognition of such concomitant growth in and stimulus to derived industry is not sufficient to attribute any foreign exchange savings obtained by the latter to investments in the key industry. The aforesaid incentives constitute an intangible benefit of great importance as an instrument of economic policy, but they are hard to express in quantitative terms.

Foreign exchange saving is usually direct, but in the case of a project where the products of the new industry have no import equivalent and whose idle capacity may serve to earn foreign exchange or substitute for imports, there may also be indirect economy. A typical example would be a mine producing for export whose activity is stopped for lack of electric energy or transport facilities. In this case a project to produce electricity or to provide a transport service will have an indirect positive foreign exchange effect.

Secondary effects should not be discounted either since, apart from the foreign exchange factor which may form part of all "backward" or "forward" transactions undertaken by the project, income variations together with marginal propensities to consume and to import have additional repercussions on the balance of payments which it would be advisable to take into account.[41]

The complexity of a project's indirect effects on the

[40] The term "positive effect" has been preferred to that of "savings", in order to maintain a neutral position as regards the method of attaining this since foreign exchange availabilities may be increased either by export expansion or import substitution.

[41] Marginal propensity to import is whatever proportion of increased income will be directed to the import of goods and services. The marginal propensity to consume represents that proportion of increased income which will be used for consumption, the remainder going to savings.

balance of payments may be appreciated from the views expressed. From the practical standpoint of an estimate of evaluation coefficient in terms of foreign exchange, to be discussed later, only the most immediate "backward" and "forward" effects, will be considered in the majority of cases.

In some cases, the inter-industrial relationships table can be used to measure the indirect effects of the project as regards foreign exchange inputs. If import substitution is considered as an increment in domestic production of the items to be replaced, and is assumed to have been individualized in the imput-product table, the concomitant increment in other activities can be determined, and, once the direct import component of each activity is known, used as a basis on which to assess the effect of such increases on the total import quantum.

The following analysis will be limited to reducing the problem to simple terms, omitting the multiplier effects and import and consumption propensities incorporated in Chenery's equations. Although this restricts the scope of the evaluation in terms of foreign exchange, it enhances the practical possibilities of estimation.

An evaluation in terms of foreign exchange may provide very important background data, but it should not be regarded as a model for deciding priorities. Its importance derives from the frequent scarcity of foreign exchange in under-developed countries.

(c) *Simple evaluation coefficients in terms of foreign exchange*

A project's influence on the balance of payments is very often indicated in terms of foreign exchange by coefficients in which the numerator represents the favourable and the denominator the unfavourable effects. In this connexion, three types of coefficient must be distinguished, each comprising total and direct effects. One type may be obtained by dividing what was previously known as the net annual foreign-exchange effect by the foreign-exchange component of investment, the result being a sort of product-capital ratio referring only to the foreign currency in question. It would primarily indicate the amount of annual increment in foreign exchange per unit of the latter invested.

The second coefficient measures the additional volume of foreign exchange availabilities per unit of the complex of input factors that the project requires in foreign currency. In the case of the first coefficient, investment productivity in foreign exchange was calculated, while, in the case of the second, the productivity of the whole volume of foreign exchange required for both investment and operation is measured. The coefficient is found by dividing the positive by the negative effect and taking into account the aggregate useful life of the project. It may be termed the foreign exchange product-to-input ratio and answers the query as to how much foreign exchange availability increases per unit of it required for the project as regards investment and operation. The third type of coefficient could be a kind of profitability of the project calculated by means of equivalence but only in terms of foreign exchange as was explained earlier.

(i) *Foreign exchange product-to-input ratio.* Equivalence formulae, whether in terms of present worth or equivalent annual cost must be used in order to take the whole of the project's useful life into account in calculating this coefficient. The most practical method would be to find the present worth of the annual negative effects and add this to investment to obtain the total foreign exchange input which will be the denominator of the above ratio, the numerator being given by the present worth of total annual positive effects.

An estimate of the type of interest to be used is particularly difficult in the case of foreign exchange. If the latter is in shorter supply than capital, its utilization would entail higher rates of interest than those on capital in general. In spite of this, rates of interest on foreign loans are usually lower than the domestic rates of interest charged on capital. In any case a rate of interest will have to be decided upon; a working hypothesis might be based on the average profitability of foreign public and private capital invested in the country.

(ii) *Foreign exchange product-to-capital ratio.* When the direct recovery of capital in foreign exchange is fairly rapid (i.e., in 3-6 years), it is advisable to take this ratio into account. Except for projects that are especially designed to solve balance-of-payments problems, the direct coefficient of foreign capital is of no special importance. For instance, as it is obvious that a hydroelectric power station is not built with the aim of saving foreign exchange, there is no practical purpose in calculating the direct coefficient, but if it is thermoelectric powered by imported coal, the negative effect will be of importance in calculating the real impact on the foreign exchange budget, but insignificant as a direct coefficient of evaluation. In a case such as this, indirect coefficient will be more useful as regards foreign exchange or any other item.

If, during the life of the project, the net effect is expected to have different annual values, they may be reduced to an annual standard equivalent by prior conversion to their present worth. This would again require the adoption of an agreed rate of interest.

(iii) *Marginal efficiency in foreign exchange.* The third coefficient mentioned is marginal efficiency in foreign exchange; this would be obtained by determining the rate of interest at which the net effects converted to present worth would be equal to investment in foreign exchange. The method of calculation would be exactly the same as that used for profitability equivalence, which has already been explained, and has the advantage of dispensing with an agreed rate of interest.

(iv) *Local conditions and accounting effects.* The significance of these criteria for foreign exchange varies according to local conditions. There are some under-developed countries which, up till now, have had no special balance-of-payments problems to face. But such problems may arise at any moment if a deterioration in income is not accepted as the inevitable consequence of stagnation or reduction in import capacity and if development programmes are adopted to offset such a deterioration.

The degree to which the foregoing coefficient reflect the true incidence on the balance of payments as estimated annually by Governments must also be considered.

In this respect, it is clear that the so-called net annual effect will not be the same as the accounting effect recorded in the balance of payments. For purposes of evaluation, the foreign-exchange component of depreciation is an annual input factor and thus a negative effect which must be deducted from the positive to give the net annual effect. On the other hand, depreciation will only appear in the balance of payments when new equipment has to be imported to replace depleted material. Similarly, if the foreign exchange product-to-input ratio is calculated in terms of equivalent annual value at a certain rate of

**Table LI**

EXAMPLE 20. BASIC DATA

*(Dollars)*

| | |
|---|---|
| Dollar component of investment | 4.0 million |
| Annual direct gross savings in foreign exchange (positive effect) | 1.0 million |
| Depreciation period and expiry date | 20 years |
| Direct annual input of foreign exchange for the operation | 0.2 million |
| Equivalent annual cost of capital in dollars (depreciation plus interest at 8 per cent) (c.r.f. = 0.10185) | 0.407 (rounded to 0.40) |

interest, the income and expenditure figures will differ from those recorded statistically in the annual balance of payments. The latter type of calculation can also be used in the project estimates, but only for financing in foreign currency.

*Example* 20. In the case of an import substitution project, the foreign exchange data may be as given in table LI.

It is desired to calculate the evaluation coefficients in terms of foreign exchange on the basis of the preceding data.

Taking the capital coefficient in foreign currency, the ratio is as follows:

$$\frac{\text{Net annual effect}}{\text{Investment}} = \frac{\text{Net annual savings}}{\text{Investment}} = \frac{0.4}{4.0} = 0.10$$

Net annual savings are 0.4 million dollars, because they represent the difference between the gross savings of 1.0 million dollars and annual input factors amounting to 600 000 dollars, including 400 000 for depreciation plus interest. The net effect investment ratio in foreign exchange is therefore 0.10. A simplified interpretation would be that the project has an annual yield of 10 per cent in foreign exchange or that the investment in foreign exchange may be recovered within 10 years. It should be noted that from the balance-of-payments accounting standpoint there will be an initial disbursement of 4 million and a net annual saving of 800 000 dollars.

The product-input coefficient can be obtained by converting initial investment to equivalent annual cost or by estimating present worth. The respective methods for doing so have already been explained and only a table of estimates at different rates of interest is given here (see table LII).

If a 6 per cent rate of interest is considered as representative, every dollar of input under various headings, including interest and depreciation, would yield 1.82 dollars. Excluding the influence of interest (final column), each dollar would produce 2.5 dollars. A higher rate of interest of 15 per cent, however, would only give 1.49 dollars for each of total input.

Finally, using table LII, it is possible to calculate the equivalence rate of interest, i.e. the rate for which the foreign exchange product-input coefficient is unity. Following the interpolation procedure outlined earlier, this rate is easily worked out to be 19.5 per cent.

**Table LII**

EXAMPLE 20. ESTIMATE OF THE FOREIGN EXCHANGE PRODUCT-TO-INPUT RATIO

*(In millions)*

| | *Percentages* | | | | |
|---|---|---|---|---|---|
| | 20 | 15 | 6 | 4 | 0 |
| I. *Present worth of annual gross income* (1 million dollars, 20 years) | 4.87 | 8.51 | 11.47 | 13.59 | 20.0 |
| II. *Present worth of annual input factors* | 4.97 | 5.70 | 6.29 | 6.72 | 8.0 |
| (*a*) 0.2 million of input factors for operating the project | 0.97 | 1.70 | 2.29 | 2.72 | 4.0 |
| (*b*) Initial investment | 4.00 | 4.00 | 4.00 | 4.00 | 4.0 |
| III. *Foreign exchange product-to-input ratio* | 0.98 | 1.49 | 1.82 | 2.02 | 2.5 |

## Annex

### Direct and indirect effects on the balance of payments

The approach and formulae used by Professor Chenery in his study, quoted, above, on project evaluation are summarized in this annex.[1]

Total effects on the balance of payments would be represented by the equation:

$$(1) \qquad \text{Total effect} = aB_1 + B_2 + B_3$$

in which:

a = combined amortization and interest rate (the capital recovery factor in the equivalence formulae),

$B_1$ = effects of the installation of the project (direct and indirect),

$B_2$ = direct effects of the operation of the project,

$B_3$ = indirect effects of the operation of the project.

Effects termed $B_1$ in the general equation will have the following two aspects: purchase of machinery and equipment abroad (direct negative effect) and multiplying effect of the investment on income and imports (indirect negative effect).

The author gives the following quantitative expression for the preceding effects:

[1] See chapter III, section II, 5, of this part. Chenery presents the problem of measuring a project's effects on the balance of payments in order to be able to quantify later the effects of different pricings of the exchange rate. This annex deals only with the estimative calculation of the effect on the balance of payments.

(2) $$B_1 = - mi\,K - m\,z\,(1 - mi)\,K$$

in which:

mi = that proportion of the investment requiring imports, directly or indirectly,

K = total investment

m = ratio of increase in imports to increase in gross national product (marginal propensity to import),

$z = \text{multiplier} = \dfrac{1}{m + s}$ y

s = marginal propensity to save.

The term (mi.K) is simply the investment component in foreign currency. The term (1 — mi) K is the rest of the investment, i.e. its component in national currency, with a multiplying effect (z) on income. The product z (1 — mi) K is, therefore, the increase in income that would result from investment in the project. Multiplying this increased income by the marginal propensity to import (m), the secondary increase in imports caused by the investment is finally obtained.[2]

Set out algebraically, the indirect negative effect of an investment on the balance of payments can be seen clearly, apart from the obvious effect through direct payments abroad.

The term $B_2$ of equation (1) represents the direct effects produced on the balance of payments as a result of the project's operation. Here Chenery distinguished between:

(*a*) production of goods to increase exports or replace imports (direct positive effect, as it is called in this *Manual*).

(*b*) direct and indirect import requirements to produce the goods in question (direct and indirect negative effect, according to this *Manual*); and

(*c*) the reduction in import requirements of other goods which can be replaced by the commodity in question (positive effect).

Chenery's equation for these effects is:

(3) $$B_2 = e\,(1 - \overline{mp})\,X - \overline{cmp}X + g\,(\overline{mp'} - \overline{mp})\,X$$

in which:

e = proportion of production which is exported or which is subtracted from imports;

g = proportion of production which replaces other goods formerly consumed; and

c = proportion of production which will increase domestic use;[3]

$\overline{mp}$ = marginal ratio between imports required for the project (direct and indirect) and the output of the project in question;

$\overline{mp'}$ = $\overline{mp}$, for the production of the other commodities which the project's output replaces; and

X = total production.

To facilitate the explanation of this formula, its terms have been regrouped: remembering that (e + g + c) = 1, expression (3) may become:

(4) $$B_2 = eX - \overline{mp}X + \overline{mp'}gX$$

Note that the three effects of the project's operations termed "direct"[4] by Chenery's expressed in quantitative terms, are as follows:

eX = production exported or replacing imports, which therefore represents a clear positive effect on the balance of payments;

$\overline{mp}X$ = the effect on imports, considering the project's direct and indirect requirements; by definition, $\overline{mp}$ is the direct and indirect need for imports per unit of the project's output; this effect is negative, hence the sign in the formula.

$\overline{mp'}gX$ = the effect resulting from the replacement, by the project's output, of other goods formerly consumed; actually, by definition, gX is that part of the project's output which replaces them, and for each unit of production of those replaced goods $\overline{mp'}$ units of direct and indirect imports are needed; the product of both factors represents the amount of imports superseded by that part of the project's production which replaces other goods formerly consumed; hence the plus sign is used.

The effects, which Chenery calls "indirect", of the project's operations are represented by $B_3$ and relate to the multiplying effect of inflationary financing of consumption (negative effect) and the multiplying effect of the change in the foreign trade balance (positive or negative).

Chenery's equation for measuring both effects is:

(5) $$B_3 = -mzf\,(1 - \overline{mp})\,X - mz\,B_2$$

in which f is the fraction of production financed by inflationary means.

For a clear understanding of the meaning of the formula, first take the term $(1 - \overline{mp})\,X$ or $(X - \overline{mp}X)$ separately. Since X is the project's annual production and $\overline{mp}$ is the amount of direct and indirect imports per unit of X, the product $\overline{mp}X$ is the imported component of production and $(1 - \overline{mp})\,X$ is the domestic component.

If, on the other hand, a proportion (f) of production X is financed by inflationary means, this will produce an increase in income through the effects of the multiplier z,[5]

$$zf\,(1 - \overline{mp})\,X$$

represents the increase in income brought about by the assumed inflationary financing. Multiplying this expression by the marginal propensity to import (m), the resultant negative effect on the balance of payments is obtained.

The term mz $B_2$ reflects the balance-of-payments effects of the multiplying power of income resulting from the balance $B_2$ which has already been explained.

By replacing the values of $B_1$, $B_2$ and $B_3$ in equation (1) according to the expressions (2), (3) and (5), a general formula is found by which the total effects on the balance of payments per unit of investment can be measured.

[2] Chenery points out that the multiplying effect is attributed by his formula to the individual project, although in fact, only the "increase" in investments has that effect on the economy as a whole. The reason given is that mi varies from one project to another.

[3] The sum of these partial outputs is total production, so that: (e + g + c = 1)

[4] The coefficients $\overline{mp}$ and $\overline{mp'}$ measure direct and indirect import needs per unit of production of the project's goods, or of the goods formerly used and replaced by the project's output; hence, in equation (3), $B_2$ measures both direct and indirect effects, although Chenery calls them direct effects of the project's operations. This clarification is purely semantic and is made to avoid confusion regarding the use of the terms "direct" and "indirect".

[5] The multiplication process is similar to that which takes place with the increase in investments.

It can be appreciated from the detail of the formulae that there are great difficulties in applying them in practice. This, in any case, will not be done by the authors of the project but by a planning board or other similar body. Whether it is applied or not, Chenery's approach offers a much broader picture than usual of a project's indirect balance-of-payments effects. It helps to show the close relationships between any project and the rest of the economy, from the balance-of-payments angle. Even if the formulae were not applicable, they do show clearly the broad scope of the indirect effects, which are very often ignored or underestimated.

## Chapter IV

## CRITERIA RELATING TO THE PRODUCTIVITY OF THE INPUT COMPLEX AND COMBINED CRITERIA

The evaluation criteria explained so far are based on the measurement of the productivity of one single resource (capital, foreign exchange, labour). The following, which refer to the productivity of the input complex and to the combination of partial criteria, are dealt with in this chapter (1) benefits-costs; (2) value added/input; (3) qualitative weighting of partial criteria; and (4) Bohr's criterion.

In both the "benefits-costs" and the "value added/input" criteria, the order of priority is obtained from the magnitude of coefficients measuring the productivity of the input complex although in different terms, as will be seen later. The remainder of the criteria mentioned are based on the combination of guiding principles relating to partial aspects of the project.

### I. The productivity of the input complex

#### 1. *The benefits-costs criterion*

(a) *The benefits-costs ratio*

When the criterion of the profitability of capital was being discussed,[1] it was seen that this criterion was applied because it concedes greater importance to those points which interest the entrepreneur: profit per unit of capital employed by the enterprise. Capital represents to the entrepreneur the power he possesses to use the varied range of productive resources. From this point of view, to the entrepreneur, profitability is the measure of the benefits obtainable per unit of total resources employed in a project.

Nevertheless, from the social point of view, the achievement of maximum production instead of just profits may be of greater interest, with the minimum of whole complex of resources (not just the capital) employed. The evaluation coefficient so defined is known as the benefits-costs coefficient and is expressed by the ratio obtained by dividing the value of production by the total costs involved. Thus the private criterion of profitability of capital becomes the social criterion of benefits-costs. Conceptually, they are identical in their respective spheres.

This conceptual relationship may be seen better if the definition of the benefits-costs criterion is reduced to an algebraic expression:

$$\text{benefits-costs ratio} = \frac{\text{benefits}}{\text{costs}} = \frac{\text{costs} + \text{profits}}{\text{costs}}$$

If P represents profits, C costs, and R the ratio, then:

$$R = 1 + \frac{P}{C}$$

R will increase in proportion to $\frac{P}{C}$, that is, the greater the percentage of profits in relation to the costs. Maximum R will therefore give the maximum profits, just as in the profitability criterion, and in both cases also per unit of resources employed. The difference lies in the fact that for society, the resources used are represented by the total costs, whereas for the private entrepreneur they are represented by his capital.

(b) *Calculation of the coefficient*

*Example 21.* Table LIII shows the method of calculating the benefits-costs coefficient, taking into account the direct effects only. Pricing is at market values. No further explanation is necessary.

(c) *Indirect effects and social pricing in the calculation of the coefficient*

If this coefficient is calculated solely on the basis of direct benefits and costs of the project—the latter at market prices—the result will not provide an evaluation which will adequately reflect the best social advantage. Projects might be considered which have a high direct benefits-costs ratio but obviously have no social priority. Such would be the case, for example, of projects for the manufacture of luxury goods from imported raw materials, in a country which not only has limited capital, but which also has balance-of-payments difficulties. A project of this nature may produce excellent profits without being beneficial to the com-

**Table LIII**

EXAMPLE 21. COMPARISON OF TWO HYPOTHETICAL PROJECTS DURING 10 YEARS OF USEFUL LIFE, ACCORDING TO THE DIRECT BENEFITS-COSTS CRITERION

*(Monetary units)*

| | *Project A* | *Project B* |
|---|---|---|
| I. Total fixed investment | 2 000 | 2 000 |
| II. Value of annual production (income) | 1 000 | 1 250 |
| III. Annual production costs (operation, maintenance, taxes, insurance) | 550 | 800 |
| IV. Equivalent annual cost of the fixed investment (at 6 per cent interest) | 271 | 271 |
| V. Total equivalent annual costs (III + IV) | 821 | 1 071 |
| VI. Benefits-cost (II/V) | 1.22 | 1,17 |

[1] See Part Two, chapter III, section II.

munity. The problem is seen even more clearly when considering projects involving investments for increasing assets in social overhead capital, such as roads, drinking water, sewerage, power stations, etc. These projects often show a low direct benefits-costs ratio, which may be less than unity or even zero if the services produced are not sold. In these cases the most important benefits are indirect, since they make production possible in other sectors of the economy.

That is why it has been proposed to amplify the benefits-costs concept to include economic repercussions on the other activities producing goods and services, that is, to include indirect effects and social pricing. Modified in this manner, the benefits-costs criterion has been specially recommended for the evaluation of projects designed to utilize and control river basins. It has been presented in its most integrated and systematic form by the Federal Inter-Agency River Basin Committee of the United States.[2] In 1946, this Committee set up a Sub-Committee, representing six Government departments, to study the economic analysis of projects for utilizing water resources. The report of the Sub-Committee, issued in 1950 after five years' work, contains specific proposals for standardizing the evaluation methods used by different Government departments. The principal object was to discover uniform evaluation methods and establish a conceptual frame of reference for the application of the recommendations.

The most important modifications to be introduced in the direct benefits-costs criterion for the evaluation of river basin control projects would be:

(1) To take into account tangible benefits which may appear in the rest of the economy as a result of the project. These are part of what has been called here measurement of indirect effects.

(2) To price costs according to the benefits which cease to be obtained from the alternative use of the resources, which is the "opportunity costs" problem.

(3) To take into account, without necessarily going into figures, the project's intangible benefits and costs, such as the deterioration or improvement of the countryside from the tourist point of view, meteorological changes, increased safety because of anti-flood measures, etc.

Although the Sub-Committee's report acknowledges the need to include indirect effects and social pricing in the evaluation, in practice they are considered only in very limited form, because of the difficulties of quantitative appreciation.

The following summary, taken from the report in question, indicates its more important aspects.[3]

(d) *Definitions*

(i) *Primary costs and benefits.* Costs and benefits will be divided into two types: primary and secondary.

Primary costs are further divided into "direct" and "associated" costs.

The direct costs of a project are the value of the goods and services used in the establishment, maintenance and operation of the project throughout its useful life; associated costs cover the preparation for use or sale of the goods or services produced by the project. In an irrigation project, for example, the direct costs are those required for placing the water at the disposal of the farmer, including those for the operation and maintenance of the irrigation works; the associated costs are those incurred by the farmer, excluding the cost of the water, in order to work the irrigated lands and produce crops.[4]

The value of the goods and services obtained from the use of resources represented by the direct costs plus the associated costs are the primary benefits. In the case of the irrigation project which is being used as an illustration, the primary benefits are the value of the wheat produced by the farmer. These provide the basis for calculating net benefits attributable to the project, which will be discussed later.

(ii) *Secondary costs and benefits.* The secondary costs are the value of the goods and services used as a consequence of the project, excluding direct and associated costs. They include subsequent manufacturing costs of the immediate goods or services of the project and all costs over and above the "direct" and "associated" costs deriving from or induced by the project. In the irrigation project, for example, the costs of transport, milling of the wheat, baking and distribution would be secondary costs.

The secondary benefits are those values which are added over and above those of the project's immediate goods and services as a result of activities which it initiates or induces. Using the same example, the difference between the value of the bread and that of the wheat which it contains would be a secondary benefit.[5]

According to the Sub-Committee, in normal cases the relative merits of a certain number of projects may be determined satisfactorily by measuring only the costs and benefits of the projects themselves, that is, excluding the secondary stage. In cases where the associated and secondary costs have special importance, or where they vary greatly between projects under comparison, it may be desirable to compare the sum of the secondary and associated costs of the projects with the gross benefits obtained.

(iii) *Pricing.* In pricing, the possibility is acknowledged in principle of applying an opportunity cost of zero if, in the absence of the project, there would have been no alternative use for the resources. There would, of course, usually be other uses. For normal cases, it is accepted that market prices may be used. Only in exceptional cases—such as pricing labour during periods of unemployment—will it be necessary to adjust the market price.

(iv) *Benefits attributable to the project.* Among all the primary and secondary benefits, the Sub-Committee singles out those "attributable to the project".

The project must be credited with the difference between the total primary benefits, as defined, and the associated

[2] *Proposed Practices for Economic Analysis of River Basin Projects,* Federal Inter-Agency River Basin Committee. Washington D. C., 1950. The same criterion is also supported by the United Nations Economic Commission for Asia and the Far East (ECAFE). *Manual of River Basin Planning* (ST/ECAFE/SER.F/7), United Nations publication, Sales No.: 1955.II.F.1 pp. 32-47, Part One of *Multiple Purpose River Basin Development.* See also *Formulation and Economic Appraisal of Development Projects,* United Nations publication, Sales No.: 1951.II.B.4, vol. I, pp. 113-146, 1951.

[3] It should be remembered that the Sub-Committee supports the criterion only for multiple projects relating to the use of watercourses.

[4] If dry-farmed wheat has been produced before, the associated costs are the greater operating costs, that is those which are incurred in addition. The income of benefits will be those obtained over and above the previous return.

[5] Standard percentages of primary benefits are often used to determine the secondary ones. These are estimated on the basis of average values added in transformation. For instance for cotton and other industrial materials produced by an irrigation project, the percentages are high (80 per cent and over), whilst they are less for primary products. (See S. V. Ciriacy-Wantrup, "Benefit-cost analysis and public resource development", *Journal of Farm Economics,* vol. XXXVII, No. 4, November 1955.)

costs.[6] In the example of the irrigation project for the production of wheat, the primary benefit attributable to the project is the market value of the wheat, less the farmer's costs but excluding from these the payments made for the use of the water which is the immediate benefit of the project.

Secondary benefits cannot be attributed to a project unless it can be shown that there is an increase in them over what would have been received without the project; all values which would in any case have been added to production in similar activities connected with the project should be subtracted from the total.

Two cases are given in which there could be secondary benefits: (*a*) where external economies are derived from the execution of the project in such a way that the goods or services were made available to secondary activities at a lower cost than without the project (thus, if the wheat to be produced by the irrigation works were to be sold at 2 dollars per unit whereas, without the project, the miller would have had to pay 2.10 dollars, there would be a secondary benefit, attributable to the project, of 0.10 dollars per unit of wheat produced as a result of it); and (*b*) when, as a consequence of the project, productive capacity can be employed which would otherwise have been idle. In the case of the example, the greater use of an existing grain elevator, because of the higher production of wheat obtainable through irrigation, would give an increase in the net income obtained from operating the elevator, which would be attributable to the project.

The determination of the secondary benefits attributable to the project is both difficult and complex. For this reason, the Sub-Committee contended that greater attention should be paid to the more direct effects in the analysis of specific projects. It was admitted, nevertheless, that the problem warranted further study.[7]

(v) *Benefits-costs ratio.* The evaluation ratio representing the criterion which is being explained is the ratio between the benefits attributable to the project and its costs. Two types of coefficients could be worked out depending on whether only primary benefits are considered or whether secondary benefits are also included.

### (e) *Benefits-costs calculation in an irrigation project*

*Example 22.* The following example refers to the application of the criterion to an irrigation project and is taken from the *Manual of River Basin Planning,* prepared by the United Nations Economic Commission for Asia and the Far East. The purpose in reproducing it is to demonstrate as clearly as possible the manner in which its supporters apply the benefits-costs criterion.

Take the case of an irrigation project for land now dry-farmed, for which the gross benefits to the farmers are 100 000 dollars per year, as against higher farm operating expenses of 30 000 dollars yearly. These advantages would begin 10 years after construction of the project has been finished, recurring uniformly over the remaining 65 years of the expected economic life of 75 years.

[6] The argument is that the associated costs represent benefits which would be obtained by the employment of these resources for alternative purposes. Their value would be the market price of such resources, except in special cases where, as explained earlier, these prices must be corrected.

[7] These studies were referred by the United States Bureau of Reclamation to a panel of consultants (John E. Clark, E. C. Grant and Maurice M. Kelso). Their report appears in the *Report of Panel of Consultants on Secondary or Indirect Benefits of Water Projects,* 26 June 1952.

**Table LIV**

EXAMPLE 22. CALCULATION OF THE BENEFITS-COSTS RATIO[a]

*(Dollars)*

| | |
|---|---|
| I. *Calculation of total annual cost* | |
| (*a*) Operation and maintenance. . . . . . . . | 10 000 |
| (*b*) Annual equivalent of capital cost (1 000 000 × 0.03367) . . . . . . . . . . . . . | 33 700 |
| Total annual cost. . . . . . | 43 700[b] |
| II. *Calculation of annual benefit* | |
| (*a*) Increase in net annual farm income in years 11-75 (100 000 — 30 000). . . . . . . . | 70 000[c] |
| (*b*) Present worth at beginning of eleventh year (70 000 × 28 453). . . . . . . . . . . | 1 922 000 |
| (*c*) Present worth of net benefits at end of construction (zero point) (1 922 000×0.7441) | 1 482 000 |
| (*d*) Annual equivalent value of (*c*) in 75 years, (1 482 000 × 0.03367) . . . . . . . . | 49 900 |
| III. *Calculation of benefits-costs ratio* | |
| (*a*) Annual benefits . . . . . . . . . . . . | 49 900 |
| (*b*) Annual costs. . . . . . . . . . . . . . | 43 700 |
| (*c*) Benefits-costs ratio $\frac{\text{benefits}}{\text{costs}} = \frac{49\ 900}{43\ 700} = 1.14$ | |

[a] Round figures.
[b] Costs of the project according to the terms explained.
[c] Benefits attributable to the project (equal to the difference between the primary benefit of 100 000 and the associated cost of 30 000).

Take the zero point as the end of the construction period. The investment at that time is one million. Operation and maintenance costs of the project are estimated at 10 000 dollars per year. Take the interest rate as 3 per cent. The calculations are set forth in table LIV.

In this method of applying the criterion, the irrigation work as such together with the greater agricultural output resulting from the availability of water has been considered as one single project. Benefits will be obtained only during 65 of the 75 years of useful life of the project, and to obtain an equivalent annual value, present worth had to be calculated for the series of 65 years (years 11 to 75). From this value, at present worth at year 11, the next point was present worth at "zero" year (item II (*c*)), and this latter was calculated in terms of annual equivalence in 75 years, thus making it comparable with the costs, calculated on the basis of the annual equivalent cost in 75 years (item I (*b*)).

### (f) *Measurement of some indirect effects*

*Example 23.* In order illustrate the calculation of a more general case, the data of example 21 will be used. The calculation will be made for project A of that example, assuming that the production of the enterprise is divided into two equal parts, half (500 monetary units) going directly to the end users and the other half being used as raw material by another enterprise. It will be assumed that the 500 monetary units of production which are distributed directly will be sold to consumers at 600, the difference of 100 being divided into 50 for profits in the distribution and 50 for distribution costs or associated costs according to the nomenclature explained above.

The 500 monetary units obtained from the sale of raw materials will provide for a production of 1 500, with total costs of 1 300 and profits of 200. The costs of 1 300 will

**Table LV**

EXAMPLE 23. UTILIZATION OF THE PRODUCTS OF PROJECT A IN EXAMPLE 21

*(Monetary units per year)*

| | *Final consumption (FC)* | *Raw material (RM)* | *Totals* |
|---|---|---|---|
| I. Sold by A. . . . . | 500 | 500 | 1 000 |
| II. Increased value . . . | 100 | 1 000 | 1 100 |
| (*a*) Profits. . . . . | 50 | 200 | 250 |
| (*b*) Additional or associated costs . . | 50 | 800 | 850 |
| III. Final value of the products. . . . . . . | 600 | 1 500 | 2 100 |

comprise 500 in payment for the raw materials to project A and 800 which are the associated costs. The distributing enterprise will be called FC and the manufacturer RM. A summary is given in table LV.

It was shown earlier (see again table LIII) that the direct costs of project A, expressed in terms of equivalent annual cost, were 821. The associated costs of project A, in table LV, will be the sum of the 800 in the enterprise RM and the 50 of enterprise FC, giving a total of 850. The benefits will be calculated as follows:

| | *Monetary units* |
|---|---|
| Production of project A . . . . . . . . . | 1 000 |
| Increase of production in the distribution FC. | 100 |
| Increase of production RM . . . . . . . . | 1 000 |
| Total benefits . . . . . . . . . . . . . | 2 100 |

The benefits attributable to the project will be the difference between the total benefit and the total associated cost (2 100 - 850) or 1 250 monetary units.

The benefits-costs ratio will be:

$$\frac{\text{Benefits attributable to the project}}{\text{Cost of the project}} = \frac{1\,250}{821} = 1.52$$

As may be appreciated from the example, in the wider application of the benefits-costs criterion the denominator is the same as in the direct case. The numerator is the sum of the value of project A's production and the profits of the enterprises which utilize it, or 1 000 plus 250 (see again table LV). The total benefit is not more than the final value of the products of A, after manufacture and distribution. Subtracting the so-called associated costs, the difference will be the profits of the derived activities, plus the cost of purchases from A. In effect, the final value of the products will be: purchases from A (value of the production of A) plus other costs (associated costs) plus associated profits. The effects of the operation of FC and RM are attributable to project A only in so far as idle capacity exists.

Consequently, the only outcome of broadening the criterion is to add to the numerator the profits of enterprises associated with the project, which naturally improves the benefits-costs ratio. This was 1.22 in project A of example 21, and will become 1.52 in example 23 which includes the hypothetical use of the products of A.

It may be seen from the example that the indirect effects have been limited to "one step forward", that is, they have considered only what occurs after the *first* sale of the goods or services of the project. The measurement of all indirect effects would require the inclusion of several of these transactions. The above calculation demonstrates the difficulties in making a complete calculation.

## 2. *Direct and indirect value added per unit of total input*

### (a) *Approach*

The object of the evaluation method proposed by Jorge Ahumada is to establish priorities on the basis of coefficients measuring the relationship between the direct and indirect added value of the project and the cost of all the inputs directly or indirectly used to obtain such added values, including among them the entrepreneur's profits.[8]

Ahumada opposes the apportionment of resources on the basis of orthodox economic theory. Briefly, according to this theory,[9] given a distribution of income and free choice by consumers, the optimum apportionment of one factor among different uses is achieved when in each case the value of the marginal product is equal to the price of the factor.

If the price of the factor is presumed to be the same everywhere, optimum distribution will be attained when the value of the marginal product obtained with the factor is the same in all uses. This argument is valid for each sector and also for the combination of factors in each use. According to orthodox theory, if competition is ideal and all the firms reap maximum profits, the optimum distribution of each factor in different uses and of combinations of factors will be attained, since in these circumstances the enterprises will shift the production factors around until the marginal product equals factor price in all directions.

In short, according to the orthodox approach and assuming a certain amount of productive resources, the optimum apportionment will be achieved when the total monetary value of the production obtained with those resources reaches a maximum. Under conditions of ideal competition, this maximum will be reached if all the producers reap the highest possible profits. Hence, if the investment projects are selected according to the profit yield, both the community as a whole and its individual members will benefit to the maximum.

Ahumada raises two basic objections to this approach. Firstly, as has been explained before, there is a difference between market prices and social prices; secondly, in practice, universal equality of factors and prices is not accompanied by economic equilibrium. Ahumada reckons that, if the price of each factor is not the same everywhere, the optimum distribution of the factors among the alternative uses will not be achieved even though the firm in question or the author of the project succeed in equalizing the value of the marginal product with the price of the factor. On the other hand, if the prices of each factor are the same for all producers, but the economy is not in a state of balance, the social opportunity cost of any product will not necessarily be equal to its market price because such equality will depend on whether the marginal product of each factor is equal in all directions. This will occur only if the economy is balanced.

Ahumada feels that the application of orthodox economic theory has given undue prominence to those criteria which imply the maximization of profits (for example, the benefits-costs criterion). When this latter criterion is applied,

[8] Jorge Ahumada, *Investment priorities*, document submitted to the round-table conference of the International Economic Association, Rio de Janeiro, 19-28 August 1957.

[9] Here Ahumada quotes Abba Lerner, *The Economics of Control, Principles of Welfare*, The MacMillan Co., New York, 1944.

market prices are corrected to allow for social costs. Nevertheless, it still implies maximization of profits. At the same time, the economy cannot be balanced while there is a state of equality in all directions between the prices of factors.

The theory advanced by Ahumada rests on two basic premises: (i) that, in selecting the criterion on which to establish priorities, it is impossible to avoid the subjective element; and (*ii*) that all investment decisions are interdependent. With respect to the first premise, Ahumada points out that, in the final analysis, the allocation of resources among alternative uses must be based on the freely expressed preferences of consumers; with respect to the second, he thinks that, from the social point of view, the proper division of a given resource between alternative uses is impossible without a clear picture of the dynamic inter-industrial relationships which portays not only movement between industries but also the relationships between the various inventories and between inventories and movements. As such a picture is lacking, the theory cannot be pursued further.

Having established these premises, Ahumada goes on to state that, if it is assumed that net *per capita* income is the closest indication of a country's social welfare, the variable which should be maximized in the establishment of priorities is the growth of *per capita* income. Given the rate of income growth, the demand for the different goods and services will depend on the income-elasticity coefficients of demand for the different types of goods and services, on the input-product coefficients and on the rate of population growth. The resulting structure of demand at a higher income level should then be compared with the structure of existing installed capacity and the final investment calculated by successive approximations. Ahumada points out that the practical application of this method involves difficulties, but any alternative method must in any case seek to raise the rate of population growth to the maximum compatible with stability. In other words, the complex of projects which makes the greatest contribution to the national income should be selected, which means that the added value of such a complex must be the maximum. If the coefficient of value added/input is used as a numerical basis for the allocation of priorities, investment resources will be distributed in the same way as if the allocation had been based on the income-elasticity of demand and on coefficients of input-product. The greater the income-elasticity of a given product or service, the greater the increase in the monetary costs involved when income rises and the greater the added value in production.

An optimum distribution of resources will only be achieved when the marginal coefficient of added value/input is equal in all directions. However, if there are various projects with different coefficients of added value/input, the allocation of priority to those where the coefficient is higher means that these high coefficients will tend to decline, while those with low coefficients will tend to rise. In other words, there is a trend towards equality.

### (b) *The coefficient of added value/input*

For the application of this criterion Ahumada proposes a formula in whose numerator the net direct or indirect value added in the project is used. This includes salaries and wages, interest, rents and profits, with all values calculated at market prices, and eliminating subsidies, taxes and tariffs. This value added must be calculated for the entire useful life of the project, using the formulae of equivalence. In the denominator all the direct or indirect resources used by the project during its useful life are computed, including profits, which are construed as payment for the services of the entrepreneur. This input is priced at opportunity costs.[10]

### (c) *Formulae*

In order to examine the indirect effects, Jorge Ahumada includes all derived effects, both backward and forward, both in the numerator and in the denominator, and thus arrives at the following equation:

$$\text{(1)} \qquad \frac{VA}{i} = \frac{VAP + VAP' + VAP''}{(CP + CP')\, r}$$

in which

VA = total value added
VAP = value added in the project
VAP′ = value added backwards
VAP″ = value added forwards
CP = the opportunity cost of the project's input
CP′ = opportunity cost required to obtain the value added forwards
r = relation between market price and opportunity cost of the items used
i = input complex.

As a result of including profits among costs (both direct costs and those necessary to obtain the indirect added values), there are only two differences between the numerator and the denominator of the formula: (i) the denominator should include capital costs (i.e. depreciation), whereas the numerator merely includes net added values; (ii) the factor r which denotes the relationship between market prices and opportunity costs should also be included in the denominator.[11]

The criterion proposed by Jorge Ahumada implies basically the measurement of the productivity of the input complex required by the project throughout its useful life. It is thus accepted, explicity and quantitatively, that the decision to install and operate an enterprise implies the commitment not only of the investment resources (capital) or other scarce resources but all those required for the project's operation. Furthermore, productivity is expressed in terms of value added, which is the most important item from the social point of view, since the basic aim of economic development is to increase the rate of growth of income. The criterion includes the consideration of the direct and indirect effects. At the same time, it meets the condition of social pricing which is essential for ensuring comparability between all types of project.

The problems involved in social pricing apply to any evaluation criterion which includes correction of market prices according to a social criterion. In this respect, Ahumada's criterion is something new, in that it prices the entrepreneur's remuneration also at opportunity cost.

Eventual attempts to apply this criterion will undoubtedly contribute greatly towards clarifying the problem involved and obtaining a more precise appreciation of the difficulties mentioned here. Since Ahumada's work was only recently published, no such attempts have yet been made.

[10] The two aspects of social pricing mentioned earlier should be remembered here: the elimination of subsidies and taxes, and the use of opportunity cost. Ahumada proposes to use the former in the numerator and both in the denominator.

[11] Ahumada states that *r* may vary not only with the type of project but also with the site. See Part Two, chapter II, section II.

1. *Qualitative weighting of partial evaluation criteria*

(a) *Bases for weighting*

The Stanford Research Institute, in a study on industrial development,[12] proposes that the choice of industrial projects should be made in two stages, one consisting in selecting "candidate industries" and the other in weighing these industries against each other on the basis of a number of criteria.[13] The first stage of project selection is subdivided into three more: one is the study of the demand; the second is a study of the availability of resources or input necessary; and the third is the preparation of a list of manufacturing industries, so as to select those whose characteristics come closest to the demand and input specifications obtained earlier. Economies of scale must also be considered in terms of the size of the market, as well as site factors.

The purpose of the second stage is to establish an order of priority among the possible industries. The industries are put to a series of tests, which involve a fresh and closer study of the local demand and input situation in relation to the industry. Finally, the results of the various tests are combined to obtain a general qualification with a view to drawing up a list headed by the industries considered to have the highest priority in the area. It should be remembered that this criterion is proposed for industrial projects only and that it is based on the assumption that problems of basic services (electric energy, transport and others) are already solved.

(b) *Partial criteria*

The recommended tests are as follows:

(i) *Net return.* The purpose of this test is to measure the ratio between industrial production and the input it requires, both from the point of view of the individual entrepreneur and from the social aspect. For the entrepreneur it consists fundamentally in the preparation of an estimated balance sheet, as explained in Part One of this *Manual,* and in calculating the return with respect to equity capital, as was also shown in earlier pages.

When considering the problem from the social point of view, the figures in the balance sheet will be modified by social pricing of the items (omission of tariffs, taxes and subsidies, and using opportunity costs). A different net income figure will thus be obtained which will now be divided by the capital.

As regard the indirect effects—both costs and benefits—the difficulties of quantifying them are pointed out. To do this, the remaining tests undergone by the possible industries are used: possible integration with other industries in industrial development; stability and growth prospects; balance-of-payments effects and socio-economic desirability.

(ii) *Integrated development.* This test refers essentially to the analysis of the new industry from the aspect of its integration in the economic complex of which it will form a part (for example, its relation to other industries or to sector, local or national development programmes). This analysis must also consider the influence which the new industry may have on the productivity of others, or on other sectors of the economy (training of personnel, improvements in marketing and transport, financial facilities, etc.). No attempt is made to quantify these factors, but only to include them in the final qualification.

(iii) *Stability and growth.* This test refers to the susceptibility of the industry to seasonal swings, international events, economic cycles and changes of other indices which reflect economic activity. It also includes the flexibility of the industry as regards its possible conversion, in the event of an emergency, to the manufacture of goods other than those provided for in the project.

This test includes an examination of the growth possibilities of the project. A study is made of the effects on the development of the enterprise in question of probable development programmes, technical innovations, changes in consumer preference, redistribution of the national income, and other factors.

(iv) *Balance-of-payments effects.* The positive and negative factors to which reference has already been made when discussing evaluation in terms of foreign exchange, will be considered broadly. The positive effects to be examined will include increase of exports, facilities which will enable other industries to increase their exports, import substitution, possible attraction of foreign capital to finance the project, etc.

The negative effects must include imports under the foreign exchange component of the investment, the need to import goods and services for the operation of the project, reduction of exports through diversion of domestic resources, increased imports due to the combined effect of greater income and the propensity to import, servicing of foreign capital investment, etc.

(v) *Socio-economic desirability.* This covers some of the socio-economic relationships connected with the advantages which an industry may offer to the surrounding community. The "surrounding community" may vary, depending on the case, from the immediate vicinity to the entire community of nations.

The type of questions covered include the human relations problems which often characterize different industries, the project's relationship to the geographical decentralization of production, the international implications of meeting unsatisfied demand or increasing the supply of a given commodity, etc.

(vi) *Experience and competition.* This test refers to the results obtained by the same type of industry in other areas or localities where the conditions were rather similar to that projected for the enterprise. The questions to be asked are: (1) Did the industry flourish, fail, or simply stagnate in other areas? (2) Did it contribute to economic development as regards production, social progress, and incentives for the creation of new industries? (3) Was it able to face competition succesfully after a reasonable settling-

[12] Standford Research Institute, *Manual of Industrial Development with Special Application to Latin America,* prepared for the Institute of Inter American Affairs, Foreign Operations Administration, United States Government, October 1954. The study refers only to manufacturing projects.

[13] Ahumada also calls attention to the problem of selecting the projects to be studied. He says that it is not possible in practice to prepare the large number of projects which would be required to cover all investment alternatives. Thus a third category of priorities is created: that of the criteria which may be used to decide which projects should be prepared in detail, within the whole range of possible studies. Here theoretical knowledge of structural changes arising in a developing economy must be employed, together with practical knowledge of a country's resources and capacity and of its bottlenecks.

down period, or did it need protection over a number of years?

(c) *Method of weighting*

The proposed tabulation of the results of each test and the method of deciding on the industries to be installed are explained below:

(i) *Tabulation of the results of each test.* When the analysis of the above six tests has been made, the problem remains of presenting the results in a form which will enable an order of priority to be established between the industries under review. The authors point out that it is impossible to provide formulae for solving this problem, or to make accurate calculations. No automatic or infallible selection system is suggested, therefore, but rather a rational procedure to assist in the formation of an opinion.

In fact, there are seven tests: profitability in the social sense and from the point of view of the private entrepreneur, and the remaining five quoted above. Social profitability—socially priced profits divided by total capital—is considered to be the most important and since it may be quantified according to relatively accurate standards, it is simple to base an order of priority on it. Tests where quantification is difficult, or impossible, are marked 1 to 5, according to the programmer's criterion, using symbols instead of numbers to show that no accurate measurement is implied.

The partial tabulation are then shown in a general comparison table, similar to table LVI below.

The order in which the tests have been tabulated in table LVI is not necessarily that described in the text. The authors emphasize that the most important criterion is that of social profitability, and the order of priority (first column of table LVI) is established on that basis. The other tests, including net return from the entrepreneur's point of view, are considered to be supplementary and are placed from left to right according to the relative importance ascribed to them in each case. Thus, for certain projects the effect on the balance of payments would be the most important and would therefore become the "first test" (second column); in other cases, stability may be more important and would thus be the first test.

If the different partial qualifications are not considered to be equally important, they should be weighted differently in the final qualification. The authors do not suggest that any arithmetical weighting should be attempted, but only that a more subjective method should be applied, leaving the signs + and —, used for the partial tests, to call attention to the outstanding features of each project brought to light during the study. By means of this subjective weighting the preliminary order of priority in the first column is modified, finally giving way to that in the last column of the table.

(ii) *Decision on the industries to be installed.* The final order of priority still does not settle the question as to which industries will be installed, and which not. A limit must still be defined within the final qualification. It is suggested that the industries which appear on the final list should be classified into three groups: those which can be installed immediately; those which must be postponed to await certain prior developments; and those, which, provisionally at least, are rejected. Yet no more precise data are provided on which to base this final classification.

## 2. *The criterion proposed by Kenneth A. Bohr*

(a) *Bases*

Kenneth A. Bohr has proposed an order of priority for the selection of manufacturing industries to be installed in under-developed countries based on the combination of four partial evaluation criteria.[14]

These deal respectively with capital and skilled labour requirements, the size of the plant and the site characteristics of the industry.

Bohr comments on the obvious influence of the first three aspects as regards selection in the case of under-developed countries. The lower the capital and skilled labour requirements and the minimum size, the greater are the possibilities that its installation will be advisable. As regards sites, industries which are widely scattered in the more advanced country, or those which are directed towards the raw materials, will generally be able to compete better against imports, or on the world markets, when installed in under-developed countries.

[14] Kenneth A. Bohr, "Investment Criteria for Manufacturing Industries in Under-Developed Countries", *The Review of Economics and Statistics,* vol. XXXVI, No. 2, Cambridge, Mass., May 1954, pp. 157-166.

**Table LVI**

TABULATION AND COMBINATION OF THE QUALIFICATIONS OF CANDIDATE INDUSTRIES

| *Tentative ranking of industries per test of social net return* | *Result of supplementary tests*[a] | | | | | | *Final ranking* |
|---|---|---|---|---|---|---|---|
| | *First* | *Second* | *Third* | *Fourth* | *Fifth* | *Sixth* | |
| 1. Industry S . . . . . . . . . | + | ± | — | ± | ± | = | 2 (M) |
| 2. Industry M . . . . . . . . . | $\left\{\begin{matrix}+\\+\end{matrix}\right.$ | $\left.\begin{matrix}+\\+\end{matrix}\right\}$ | ± | ± | + | + | 1 (S) |
| 3. Industry K . . . . . . . . . | — | — | $\left\{\begin{matrix}+\\+\end{matrix}\right\}$ | ± | — | + | 3 (K) |
| 4. Industry H . . . . . . . . . | ± | ± | + | — | + | — | 4 (H) |
| 5. . . . . . . . . . . . . . . | | | | | | | |
| 6. . . . . . . . . . . . . . . | | | | | | | |
| etc. . . . . . . . . . . . . . | | | | | | | |

[a] = signifies 1; — signifies 2; ± signifies 3, + signifies 4, and $\genfrac{}{}{0pt}{}{+}{+}$ signifies 5.

(i) *Capital requirements.* Bohr begins by stressing the importance of allocating the little available capital in under-developed economies to the most productive uses. In his opinion, the fact that these economies are basically in need of investment in social overhead capital (transport, power, housing, etc.), which is not directly productive, emphasizes the importance of investing in manufacturing industries with low capital requirements, if this is compatible with the other investment criteria.[15]

Bohr measures capital requirements by the ratio between fixed capital and value added, that is, by the so-called coefficient of capital, which is the reciprocal of the capital-product ratio, as explained earlier. He tabulated correlatively the capital coefficients for a number of industries in different countries, so that those requiring the least capital per unit of value added headed the list. On the basis of available data, it was generally found that clothing, leather goods and furniture industries have low capital requirements in all cases. In the textile industry the capital coefficient varies considerably, but is relatively low in many cases. Chemical products, non-metallic minerals (bricks, cement, etc.) and paper are relatively high. Beverages, foodstuffs and tobacco always have a high capital coefficient.

Data of this type will vary from country to counrty, but a very close relationship was seen between the United States and Australia for the groups at the two extremes of the list (high and low capital intensity), although the remaining industries varied widely.

Bohr admits the need for more detailed studies by countries and also of the composition of capital, in order to allow for the proportion of imports required by the fixed investment. A rough estimate of this last problem can be made by dividing the capital data into two groups: "plant and equipment" and "land and buildings". The amount of the former may be considered to give an approximate indication of the import component of the investment.

(ii) *Skilled labour.* The needs for skilled labour were measured by taking the percentages of professional technicians, skilled workers and foremen in the total labour force.

(iii) *Location.* Bohr maintains that, from the point of view of competition with foreign products, developing countries should take special interest in industries where transport costs give an advantage to the domestic producer. These industries may be indentified by their site pattern in developed countries. They generally fall into two categories: widely scattered industries; and those directed towards sources of raw materials but not included in the first group.

A plant in the former category should not normally fear competition from enterprises more than a limited distance away; this group includes industries whose site is directed towards the market, or towards widely scattered raw materials.[16] Under-developed countries can develop in particularly favourable conditions those industries directed towards local raw materials, including processing for export (e.g. sugar, tea and copper).

Bohr proposes to measure the distribution of industry by means of a so-called coefficient of localization.[17] He obtains this as follows:

(1) He divides the country into a series of regions (for this purpose, the United States was divided into 34 regions, and the United Kingdom into 10).

(2) He calculates the percentages of manufacturing workers in each region in relation to the national total. (This percentage will be referred to here as P.T. to simplify the explanation.)

(3) He calculates the percentages of workers in each area working in the particular industry, in relation to the national total in that industry. (This percentage will be called P.E.)

(4) He establishes the difference (P.E. — P.T.) for each region, thus obtaining a series of "deviations", some positive and some negative.

(5) He adds the positive deviations of the various regions, and divides by 100, thus obtaining the "coefficient of localization", which he uses to measure the geographical concentration of a particular industry, compared to the distribution of all industry in the country. A zero coefficient means that the distribution of workers in the particular industry coincides exactly with the distribution of industrial workers in general (zero deviations). The greater the coefficient, the more highly concentrated geographically will be the industry.[18]

(iv) *Size of the industry.* The inclusion of this factor is based on the fact that industries need a certain minimum scale for economic operation. Size was measured by the number of employees. Industries were thus classified in a rising correlative scale, according to an index of the predominant size of plants in each industry. Industries where smaller plants predominate head the list.

Bohr considers that industries with a definite tendency to small plants (greater frequency of plants with a relatively small number of workers) will be of special interest

[15] These other criteria may be of primary importance in many cases. For instance, the installation of a capital goods industry may receive priority because of its stimulating effect on economic development, even though it is of high capital intensity. [Author's note].

[16] Although Bohr is not very explicit on this point, the advantages of this group must be in respect of freight and minimum size, which would be less in more scattered industries.

[17] P. Sargent Florence. *Investment, Location and Size of Plant,* Cambridge University Press, 1948, pp. 35-36.

[18] It should again be stressed that this is a measurement of the relative distribution of an industry in relation to the geographical distribution of all industry. For an under-developed country the calculation of the coefficient might indicate considerable dispersion of one industry, when in fact all industry, as well as that under review, is concentrated in two or three places which are the only manufacturing centres in the country. [Author's note].

**Table LVII**

COEFFICIENTS OF ECONOMIC CHARACTERISTICS FOR SELECTED INDUSTRIES[a]

| *Industry* | *Total fixed capital requirements* | *Machinery & equipment requirements* | *Skilled labour requirement* | *Localization coefficient* | *Predominant Size* |
|---|---|---|---|---|---|
| Footwear | 1 | 3 | 1 | 3 | none |
| Soap and candles | 1 | 1 | 3 | 2 | none |
| Leather goods | 1 | 1 | 1 | 2 | 2 |
| Paints and varnishes | 1 | 2 | 2 | 1 | 2 |
| Furniture | 2 | 1 | 4 | 2 | 1 |
| Textiles and synthetics | 4 | 4 | 3 | 4 | 5 |
| Chemical fertilizers | 4 | 4 | 1 | 4 | none |
| Petroleum refining | 4 | 4 | 4 | 4 | 4 |
| Bakeries | 4 — 1 | 1 | 1 | 1 | 1 — 2 |
| Paper making | 4 — 3 | 4 | 3 | 1 | 3 |
| Flour milling | 4 — 2 | 3 | 4 | 3 | 1 |
| Butter | 4 | 3 | 1 | 4 (R.M.)[b] | 1 |

*Source:* K. A. Bohr, *op. cit.*
[a] Only part of the table is reproduced to serve as an illustration.
[b] (R.M.) indicates location near to raw material source.

to under-developed countries. It is also suggested that the classification of the predominant size could be further qualified by considering the economic minimum size.

### (b) *Tabulation of results*

The industries under comparison may be ranked according to their advantages and disadvantages in terms of each of the factors, allotting 1 to 4 for each factor except that of prevalent size, in which there will be 5 groups or classes. The lower the numerical classification coefficient, the more favourable the characteristics.

The result of the final classification is as shown in table LVII.

It must be added that the figures in table LVII refer to data for different countries at different dates, because of the difficulty in compiling them. Bohr remarks that this fact does not lessen the validity of the results, since the values are relative and since subsequent research has revealed that, even when comparing different countries and dates, a similarity exists between these values.

### (c) *Application of the criterion*

The criterion is applied to each specific case by comparing the favourable and unfavourable factors, without attempting to calculate a single priority coefficient. Taken separately, none of these characteristics may be considered as an adequate criterion, and the relative importance of the factors will vary between countries.

It is not, therefore, a question of calculating a single coefficient nor of establishing a priority list, but simply of comparing a specific project within the general frame of reference provided by table LVII.

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Printed in Mexico
58-27891-4,400

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United Nations publication
Sales No. 58. II. G. 5
E/CN.12/426/Add. 1/Rev. 1
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