6-1-1968

Economic project evaluation and development planning: An applied study

Samir Abdel-Messih Attia
The American University in Cairo AUC

ECONOMIC PROJECT EVALUATION AND DEVELOPMENT PLANNING AN APPLIED STUDY

---

by

Samir Abdel-Messih Attia

A thesis submitted in Partial Fulfilment of the requirements for the Masters Degree in Economics.

The Department of Economics
American University in Cairo
Cairo, U.A.R.

June, 1968

ACKNOWLEDGEMENTS

I wish to express my deep gratitude to my supervisor, Professor M.A. Ghali for his genial guidance, encouragement and helpful advice.

The auther would like to thank Professor R. Kahil for his suggestions and valuable discussions.

Many thanks are due to Professor C. Cannegieter for his constructive criticism and enthusiastic support.

Thanks are also due to Mr. A. Hassan for his able manipulation of the electronic computer.

Finally, I would like to thank Mr. G. Christodoulou for his assistance in submitting this work.

PREFACE

The process of economic project evaluation is one of the most important steps in development planning.

Its purpose is to establish priorities among projects in order to select the best projects to be included in the plan.

This paper is an applied study of the techniques of economic project evaluation. The first Chapter is a short survey of the formulation of a development plan, place and importance of project evaluation. The project, as a method of resource allocation, is the subject of Chapter Two. There, we discuss the different types of projects, the initial selection, and the formulation of a project. Chapter Three deals with the problem of valuation (Pricing) of goods and factors of production. The disequilibria of the economy make the market prices unrepresentative of the opportunity cost of the factors of production and goods. Therefore, the "true" value should be calculated in order to insure the consistency as well as efficiency in production.

In Chapters Four and Five, we study the alternative techniques of the economic project evaluation. Two approaches are investigated. The first approach is the application of a partial criterion related to the productivity of a single factor of production. The second - what we termed, the comprehensive criteria - is established by the application of linear programming techniques.

The study examines the extent to which each of these techniques is applicable, particulary when the objectives of development are multidimensional.

Chapter Six, is an applied study including a suggested method based upon the application of linear programming technique to the metallurgical branch of the industrial sector in the U.A.R. Since no account has been taken in the applied study of either the indirect effects (the external economies) or the problem of pricing, it should serve more as an example than as a policy guide.

TABLE OF CONTENTS

Page

CHAPTER IV.

THE TECHNIQUES OF ECONOMIC PROJECT EVALUATION

CHAPTER V.

THE LINEAR PROGRAMMING TECHNIQUE

CHAPTER VI.

CHAPTER I

I N T R O D U C T I O N

I. OBJECTIVES OF ECONOMIC DEVELOPMENT

Economic development should not be left to the vicissitudes of the economy. It requires a deliberate effort on the part of the government. Economic development may be furthered by what is called development policy. Therefore, any comprehensive approach to the resource allocation problem of a given underdeveloped country should begin by considering the different objectives of its development policy. The objectives that are most commonly accepted include (1):

a) A rapid increase in per-capita income.

b) A high level of employment.

c) Equilibrium in the balance of payments.

d) A relatively stable price level.

e) Improving the distribution of income by regions and social classes.

f) A diversified economy.

Although each of these objectives may be desirable in itself, there is a possibility of conflicts between them. These conflicts cause great difficulties in the evaluation of projects. It is, therefore, necessary to determine in the

---

(1) E.C.A.F.E. Programing Techniques for Economic Development. Series No. 1, U.N. Bangkok 1960, P.6.

light of the situation of each country, the major objective or the objectives to which precedence should be given in planning. Usually the important objectives for most of the underdeveloped countries are the first three of the above mentioned objectives.(1)

The employment objective, for example, may be the most important one, if a country faces a rapid expansion in the work-force. Usually, the objective of a rapid increase in per-capita income is given high priority, since the source of material well-being is the availability of goods. The other objectives will then constitute what is called "Side Conditions"(2) to be realized as far as possible in the course of pursuing the main objective. In this study, we propose an alternative technique which allows for the maximization of a multi-dimensional objective function.

For achieving the objectives of economic development, most underdeveloped countries have adopted planning techniques.(3) The purpose of planning is to assure consistency

---

(1) E.C.A.F.E. Formulation Industrial Development Programming. Series N° 2,U.N. Bangkok 1961,p. 10.

(2) It is an expression in mathematics meaning constraints laid upon the system. See W.J. Baumol, Economic Theory and Operation Analysis, 1961, Prentice-Hall, INC., NJ., p.66.

(3) Two approaches of planning may be applied. (i) Target setting-approach,based on fixed targets. (ii) Optimality approach,based on flexible targets. See M.M. El-Emam, Planning for Economic and Social Development,Arab League, The Institute of Higher Studies 1965, p.28.

and to avoid large scale waste of resources. Application of planning techniques depend on several factors(1):

i. The stage of development that has already been reached.

ii. The availability of the requisite data.

iii. The quality and size of the agencies responsible for planning.

iv. The quality of technicians.

Planning is usually undertaken on stages, drawing the main lines first and specifying details at the later stages.

---

(1) E. Engert, The role of Industrialization in Development Memo. N° 384 I N P. Cairo U.A.R., P. 8.

II. STAGES OF DEVELOPMENT PLANNING

Once the objectives of the development are fixed, the analysis required may start at the aggregate level or at the individual project level, but in the end their results must be reconciled. Analysis takes place in at least three stages or levels of generality.(1)

a) Aggregate stage.

b) Sectorial stage.

c) Project stage.

a) Aggregate Stage :

The aggregate stage provides a framework for the projection of national income or Gross National Product, the supply of economic resources and the balance of payments. Given the initial projection of gross national income over the planning horizon, the next step is to break it down by use into private consumption, gross investment, government expenditure and exports. The sum of these elements must be equal to the total resources available to the economy, including imports.

In symbols :

$$V + M = C + I + G + E$$

(1) J. Timbergin Original stage method consists of the macro stage, sectorial stage, regional stage and the project appraisal stage. See B. Hansen, The Theory of Economic policy and planning Part II INP. Cairo, UAR p. 123; also E.C.A.F.E., Development Programming Techniques, Series No. 2 Bangkok 1961, P.11.

Where :

V = Gross national income

M = Imports

E = Exports

C = Private consumption

G = Government consumption

I = Investment (Public and Private)

b) Sectorial Stage :

At the sectorial stage, planning passes from the more general to the more specific and provides a frame-work for the initial selection of investment in the different sectors. If projects are grouped according to their technological properties, sectors such as agriculture, fisheries, oil extracting, textile industries, etc., a sectoral plan is formed. If projects are grouped according to location we get regional planning.(1)

The problem at this stage is the estimation of final demand for each sector. Final demand can be defined as that part of production which is not devoted to further production. Once the final demand for each sector is estimated, the corresponding output can be determined using input output table.

---

(1) I.H. Abdel-Rahman, Comprehensive Economic Planning in U.A.R. Memo, No. 235 Sept. 1962 I N P. Cairo, U.A.R., P. 21.

c) Project Stage :

In the preceding stage - sectorial stage - the output and the investment required for each sector have been determined. The project stage provides the framework of selection of projects to be included in each sector within the limits of the available resources, to realize the objectives of the sector in question. The analysis in the project stage becomes narrower in scope and more specific in content.

This results in a detailed programme of individual investment projects, forming the plan in its final shape.(1)

The analysis of the three stages ideally must satisfy the following conditions :

(i) Consistency, which refers to the balancing between supply and demand for commodities as well as factors of production.

(ii) Efficiency, which refers to making the best choice among investment projects in the light of the aims of the development plan.

(iii) Workability, which refers to the degree of effectiveness with which these investment projects may be translated into action(2)

---

(1) For more details, see H. Linnemann, Lecture Notes on Economic Development Planning Memo, N° 269 INP. Cairo, U.A.R. P.15.

(2) H.B. Chenery, "Development Policies and Programmes", Economic Bulletin for Latin America III (March 1958), pp.60-61.

III. THE IMPORTANCE OF ECONOMIC PROJECT EVALUATION

The problem facing the planner at the third stage of planning is the selection of the project to be included in the plan. It is impossible, however, to determine the best choice directly, because there are no complete data and information about all the possible alternative Projects.(1) Known projects may be considered directly in the projects programme, but there exists a large number of alternative projects unknown to the planner, some of which might be superior to those under his consideration. "It would be a miracle that the planner hits on the right projects without studying a number of other projects".(2) For this reason the planner has to be faced with a much larger collection of projects than the collection he will finally select. In order to solve this problem, faced with such a large number of projects, the planner can apply some techniques of project evaluation in order to choose the best set of projects.

---

(1) J. Tinbergen, The Design of Development, The Johns Hopkins Press, Baltimore, 1958, p. 29.

(2) Formulation and Economic Appraisal of Development U.N. Volume I 1951, P. 223.

Economic project evaluation can be defined as "the assessing of the quality of the project and to compare it with other projects according to a certain scale of values, in order to establish the order of priority".(1) It is the process by which one can select the best projects, i.e. the projects which have maximum net advantage from the national view point.

Priority may be established among alternative technologies for a single project, and/or among a number of alternative projects under a certain set of conditions such as a limitted capital. Alternative projects may be among. (i) Building a new plant versus modernizing and expanding the existing plant. (ii) Capital or labour intensive variants of projects. (iii) Alternative locations of an investment projects.(2)

---

(1) Manual on Economic Development Projects, U.N.E/CN.12 /426 Add. 1/Rev. 1, P.10

(2) "Evaluation of Projects in Centrally Plannted Economies" Industrialization and Productivity, U.N., Bulleten 8, N.Y. 1964 P. 16.

The economic project evaluation process implies, in the first place, forcasts, and inevitably involves risks with regards their accuracy. It is commonly known that some of the hazards and contingencies confronting any enterprise can be determined, but this does not take into account the miscalculation made at various stages of project study which may be so serious as to doom the project to failure. Therefore, the study and the calculation in the forecasting for the decision making of investment have to be made as accurately as possible. Furthermore, it is essential that an adequate method of project evaluation is used, particularly in the framework of economic planning of a centralized nature, for all major decisions of investment allocation.

CHAPTER II

THE PROJECT

I. PROJECT DEFINITION

There are different economic methods designed to promote efficient use of resources, the most important of which is the formulation and evaluation of projects. The project is defined as "a compilation of data which enable evaluation to be made for the economic advantage and disadvantage resulting from the allocation of a certain part of a country's resources",(1) to the production of a certain commodity by a certain technique. Generally, it represents inputs used over some time horizon and the output produced over that horizon.

The projects may aim directly at one or more of the objectives of economic development, but they may also take the form of supporting activities to development.(2) For instance, distribution and trade projects depend on the existence of producers and consumers, and at the same time, support production and consumption activities. Transport, banking and insurance are services supporting general economic activities. Education and training, on the other

(1) Manual on Economic Development Projects, U.N., New York 1958 E/CN. 12/426/Add. 1/Rev. I, P.XIII.

(2) I.H. Abdel-Rahman, Comprehensive Economic Planning in the U.A.R., Memo. No. 238 Sept. 1962, INP Cairo, U.A.R., P. 18.

hand, eventually increase skills in the society and change the structure of demand on final goods and services. Given this definition, the project will be influenced by its nature, but it will also be affected by Socio-economic policy consideration. For example, primary education is generally considered a non-revenue producing activity, but in some countries secondary education is treated as a revenue producing activity. Infra-structure projects are complementary to other activities, that is, their justification is fulfilled in conjunction with other related activities. The justification of such projects have to be made for the original project and the complementary project which are needed to support the original project.(1)

Comprehensive Planning should recognize the different characteristics of projects, whether directly developmental, supporting, leading, consequential or infra-structure, so as to form an integrated and balanced group of them to be executed in the planning horizon.

---

(1) B. Hansen, The Theory of Economic Policy and Planning Part II, 1964 INP. Cairo, U.A.R., P. 126.

The basic points in defining a project are, therefore, as follows :

i. The aim of any project is to produce certain well defined goods and services. One should avoid running after broadly defined targets, such as the increase of national annual income, the welfare of the society or the improvement of transportation.

ii. The production of such commodities or services requires a certain amount of resources not to be used in any other alternative project.

II. INITIAL SELECTION OF PROJECTS

The initial selection of projects to be studied for a plan requires establishing some criteria and methods to be adopted. Strictly speaking, this is more of a problem of general programming technique than one relating to the study of individual projects. The project selection criteria given below do not mutually exclude one another, and should be considered as suggested methods to be adopted to the circumstances of each problem.

(i) Technical complexes:(1) A list should be made of all possible projects in each sector. It should then be revised to form technically integrated groups of projects. For example, if the manufacturing sector programme includes the substitution of imported newsprint by domestic production, the investment project would appear on the list of the manufacturing projects. However, this project will be dependent, by virtue of derived demand, on forestry, road, rail and electric power projects, pertaining to the primary or services sector.

---

(1) Manuel on Economic Development Project, op.cit., p.6.

(ii) Geographic Complexes : From the location point of view, once the production target for each sector has been fixed and the basic natural resources ascertained, a group of projects could be formed on a regional basis. For example, in the case of the paper industry based on domestic forests, the location should be determined giving adequate consideration to other projects which will be established in the region. This assures the formation of a plan with well-integrated geographic complexes.

M.D. Bryce has given an excellent summary of the alternative ways that can be used to identify new potential projects.(1) These methods should be used simultaneously since they supplement each other :

i- Market researches. The study of import structure will reveal the structure of existing demand, thus suggesting new opportunities for projects to satisfy such proven demand.

---

(1) M.D. Bryce, Industrial Development, A Guide for Accelerating Economic Growth, McGraw-Hill Book Company, INC., P. 19-20, See, M.J. Solomon, Course # 529 - Quantitative Techniques for Development Planning, Winter Trimester 1962-63. Graduate School of Public and International Affairs, University of Pitisburgh, P.12.

ii- Investigation of local materials supplies: If there exists a certain advantage in the quality or the price of certain raw materials or other factors of production, this may create opportunities to produce certain goods competitively for export and for domestic market.

iii- Studying available skills: Labour and management skills which have already been developed in the area, such as in making handicraft items or industrially manufactured goods, may suggest the possibility of producing other goods requiring similar know-how.

iv- Study of Industry: Many good opportunities are to be found in expanding or diversifying industries already established. The analysis of existing industries may lead to identifying logical new projects.

v- Apply technology: Changing technology continually creates new industrial opportunities which can be identified by re-examining local raw materials and existing products in the light of current scientific and technological advances.

vi- Examine Inter-Industry Relationship: The growth of one industry may create opportunities to establish others. The identification of these possibilities can be done by analyzing how the inputs and outputs of industries are related.

vii- Review old Projects: Projects previously developed but not implemented often become feasible when markets or related industries have changed. It is often possible to find new opportunities in old ideas for which the economic circumstances have improved.

viii- Observe experience Elsewhere: Familiarity with current industrial development in other countries or regions having somewhat similar conditions will often suggest the possibility of projects which have been successful elsewhere.

ix- Using Industry Lists: Industry lists such as the standard industrial classification of the United Nations or the U.S. Government provide systematic check lists of opportunities. They are useful for suggesting ideas and for making sure that no possibilities have been overlooked.

III. THE PREPARATION OF A PROJECT

For the preparation of a project the following interrelated steps should be taken.(1)

(i) Market Study for the Products. This stage of project study is complementary to the study of initial selection of projects which have been discussed. However, it may be worth discussing in more detail the methods of forecasting future demand.

By studying the market for a product, one should try to determine the key variables that affect the demand. Some products are especially sensitive to price variations, others are complementary to allied activities (Cement in Construction, Pipes with dam construction). The studies of imports and the actual production of the commodity in question is also important as a method of demand investigation.

The domestic consumption of some commodities may be estimated by the following method:(2)

$$\frac{C_i}{N} = \overline{C}_i \left(\frac{Y}{N} \right)^{\alpha} \qquad 2.1$$

---

(1) For more detailed study, see manual on Economic Development Projects. op.cit, pp. 11-193.

(2) E.C.A.F.E. Development Programming Techniques Series No. 2 op.cit., p. 14.

where :

C_i = Total consumption of commodity i

N = Population

$\frac{Y}{N}$ = Per-capita income

α = income elasticity of demand

$\bar{C}_i$ = A constant.

Total consumption from commodity i is therefore:

$$C_i = \bar{C}_i \left(\frac{Y}{N}\right)^{\alpha} \cdot N \qquad 2.2$$

Consumption in year "t" can thus be expressed in terms of consumption in the base year C_i^o , the annual growth in per-capita income, r, and the annual growth in population P as :

$$C_i^t = C_i^o (1 + r)^{\alpha t} \cdot (1+P)^t \qquad 2.3$$

(ii) Project engineering include a technical description of the project, and deals with the 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, the justification of the degree of mechanization adopted, the technical problems and flow diagrams covering the installation and operation of the project and work schedules are technical data required for the formulation of the project.

(iii) Size and location: In the light of the demand studies, production capacity of the project, and the location of the new productive unit, have to be determined.

(iv) Investment : Calculations of the total investment required in national currency (local) and foreign currency, taking into account both the investment in fixed assets and in working capital have to be made.

(v) Budget of Income and Expenditure, and arrangement of Data for evaluation :

a - Estimation of costs and income which will result from the operation of the project.

b - A systematic form has to be used for determining the information which may be required to evaluate the project; that means, to determine the advantage and the disadvantage for a certain allocation of limited resources, such as the effect on the national income, balance of payments and availability of labour.

c - The life span of the project.

(vi) Financing of the Project: the source of financing has to be specified, together with the manner proposed to channel these resources for the execution of the project.

(vii) Organization and execution: the proposed solution of the problems of legal constitution of the project, and the organization for the execution of the project, should be available.

CHAPTER III

THE PROBLEM OF VALUATION

The process of project evaluation is the final step for project selection. Therefore, we have to assure efficiency in production and resource allocation for the selected programme of projects. "Efficiency is usually taken to mean getting as much as possible out of the limited available resources"(1). Two of the necessary and sufficient conditions of efficiency in production are that the value of the marginal productivity of each factor has to be the same in all production lines,(2) and that the technical rate of substitution between factors is equal to their price ratio.

In evaluating alternative projects, one needs a set of factor prices. The set of factor prices which correspond to production efficiency should be used. Such a set will result, under certain assumptions, in a perfectly competitive market. Therefore, if the conditions of perfect competition prevail, market prices for factors of production can be used directly for project study and evaluation, since prices will reflect the society's valuation.

---

(1) B. Hansen, Lectures in Economic Theory Part III, The Theory of Economic Policy INP. Cairo, U.A.R. 1963, P. 41.

(2) S.F. Hassan, Introduction to Welfare Economics, Asia Publishing House, Bombay 1963, P. 47.

Professor H.B. Chenery[1] discussed the equilibrium market prices and priorities. He concluded that, profit calculation based on the equilibrium market prices leads to optimum investment provided that :

(i) Stable market existed

(ii) Economies of scale were small

(iii) Changes in sector's production have been dually anticipated by investors in other sectors.

One should point out, however, that Prof. Chenery's conditions are not sufficient for optimal resource allocation. His conditions will guarantee that a perfectly competitive market, with perfect foresight will maximize the output valued from the private point of view. To be a social optimum, one must add the condition that private and social valuations are identical; that is, there exists no externalities. To the extent that this condition is violated, the perfectly competitive market solution, along with the resulting set of equilibrium prices will not correspond to the socially optimum solution. Should externalities exist, achieving

---

(1) Manual on Development Projects, U.N. op.cit., P. 206

optimum allocation will require an action on the part of the government to correct the allocation either directly or via adjusting prices. The same argument applies to the cases where indivisibilities, imperfect forsight or market imperfections exist.

Government will have, therefore, the responsibility of first finding the optimal set of prices, and then either adopt them or try to adjust market prices to the optimal set via some tax-subsidy policy. It is my belief that it may be easier for those economies to let the price fixing completely in the hands of the government, than to correct the market prices, since both require the same amount of information.

The optimal set of prices are frequently called "Shadow Prices". The price of the factor of production equals the value of the marginal product and the price of each commodity equals to the marginal cost of production.(1) Prices for the scarce factors of production - short in supply - will be higher, while factors that are in a great supply will be lower.

---

(1) J. Tinbergen uses the accounting prices with the same meaning of the shadow prices, i.e. the opportunity cost implied by a given resource allocation. Represents the loss to the economy that would result from the reduction in its supply by one unit. See, H.B. Chenery, "Comparative advantage and Development Policy", American Economic Review, Vol. 1, March 1961, P. 31.

For the purpose of planning, accounting prices[1] have to be calculated for the scarce factors of production such as capital, foreign exchange, skilled labour and some time for a few basic commodities.

(i) Labour :

In most of underdeveloped countries there is a number of fundamental disequilibria. The most important one is the wide spread unemployment, open and disguised, indicating that the equilibrium level of wage rate will be considerably less than the market wages. Market wages are determined by governments or trade unions which have the responsibility to fix the legal minimum wage rate. Therefore, unemployment does not lead to a decline in the actual wage rate. Hence, market wage rates do not reflect the opportunity cost of labour. In order to determine the accounting prices of labour, some factors have to be considered.

---

(1) A. Quyme distinguishes between three types of accounting prices. i) Marginal accounting prices. ii) Cumulative marginal accounting prices. iii) Over all accounting price For more details, See A. Quyme, Theory Aid Policy of Accounting Prices, contribution to Economic Analysis, Amesterdam 1960, PP. 76-119.

i- If we distinguish between the installation cost of a project and its production cost. If the site of the project, work condition and the time required, are known, it will be comparatively easier to estimate the opportunity cost of the labour employed in the installation work. If there is a certainty that labour employed in the operation of construction are previously unemployed, and that there are no possibilities of their placement in other activities, "an opportunity cost of zero might be considered, plus the cost necessary to move the factor to the project".(1) This may occur, for example, in the case of projects which take advantages of seasonal agricultural unemployment.

ii- The greater differences between accounting prices and market prices occur in unskilled labour and un specialized employees.

iii- For the absence of more specific data, a percentage of the market prices may be adopted to all labour in all projects under comparison, without taking into account technical site differences.

---

(1) J. Tinbergen, The Design of Development, op.cit, P.86.

(ii) Capital :

The rate of interest is the cost of using capital. The market rate of interest in most underdeveloped countries is determined by low or by other regulations. The important problem of underdeveloped countries is the shortage of capital. Therefore, the real cost of capital often exceeds the market rate of interest.

The real rate of interest is important for project evaluation because it affects the desirability of the projects from the national view point. If there is a great difference between market and accounting prices of capital, projects priority have to be changed. Generally, equilibrium interest rates are much higher than market rates. Some indications of equilibrium interest rates may be derived from(1):

(i) The rate of which it would be possible to attract additional capital and (ii) the profitability of marginal projects, corrected for risks involved. In this respect, Prof. Tinbergen(2) mentioned an important indication for the influence of the price of capital may be obtained if an interest rate of some 10% is used alternatively to the rate for which the International

---

(1) J. Tinbergen, Economic Policy: Principles and Designs North - Holland Publishing Company, 1965, P. 185

(2) _____, The Design of Development, op.cit. P. 90.

Bank for Reconstruction and Development makes loans. In some cases, when it is difficult to obtain figures of any accuracy, a relatively arbitrary estimate may sometimes be preferable to using the market rate.

(iii) Foreign Exchange :

An important accounting price, that may sometimes be estimated on a priori grounds, would seem to be the rate of exchange, if there is a disequilibrium in the balance of payments. The accounting prices of foreign exchange can be made on the basis of an over-all model of the economy, not even showing separate sectors for each of the projects, where the exchange rate would be an equilibrium rate. Accounting prices of foreign exchange would be equal, "in an optimum development plan, both to the increment cost of earning foreign exchange through exports and to the incremental cost of saving foreign exchange through import substitution."(1)

The shadow prices may be determined directly by the application of a linear programming technique.(2) Associated with the programming problem of optimal resource allocation, there exists a set of equilibrium shadow price.(3) A more detailed discussion of linear programming technique is provided in Chapter V.

---

(1) E.C.A.F.E., Series, N° 2, op.cit. p.18.

(2) H.B. Chenery, op.cit. p.35.

(3) For the Computation of the shadow prices for the scarce factors of production, See. Dorfman, Samuelson and Solow, Linear Programming and Economic Analysis, McGraw-Hill Book Company, INC., N.Y. 1958, pp. 158-170.

CHAPTER IV

THE TECHNIQUES OF ECONOMIC PROJECT EVALUATION

(1) PROJECT EVALUATION: A GENERAL VIEW

Ideally the Planning Agency should select the projects with maximum contribution to the objectives of development with the minimum use of scarce resources available. In order to solve this problem, the techniques of economic project evaluation should be applied. The role of such techniques is to determine, (i) the advantage and the disadvantage of the project, i.e. its contribution to the objectives and the scarce resources used by the project, (ii) ranking the alternative projects to determine priorities.

Economic project evaluation is sometimes based on the application of evaluation criteria related to the productivity of a single factor of production: partial criteria(1). Others are based on criteria related to the productivity of the complex factors. This means that, the denominator of the evaluation coefficient may consist of one scarce factor of production such as capital, labour, foreign exchange, etc.... or of the complex of these factors. The evaluation coefficient may be defined mathematically as the ratio between what is in general terms called the "advantage" and the "disadvantage" of the project.

---

(1) The term productivity is used in the sense of volume of production (or other benefits) obtained per unit or complex of resources. 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.

As a general rule, the characteristics of the evaluation criteria to be adopted should be as follows :

(i) The criterion used should be applied consistently and uniformly to all projects.

(ii) The criterion should be used as a guide rather than the sole basis for approval or disapproval of capital projects.

(iii) Managers should understand how the computation is made and what the answers really mean.

The order of priority among the projects may be established according to the application of a single coefficient, or by the application of a combination of partial criteria, weighted in some manner.

The techniques of economic project evaluation can be applied in a private enterprise system, as well as for the projects which are included in a development plan, i.e. from the national point of view. In other words, the limited available resources of a country may be allocated according to the individual interests or the national interests. The individual interests are typically taken as the achievement of maximum private profit(1).

---

(1) M.D. Bryce, Industrial Development, McGraw-Hill Book Company Inc., N.Y. 1960, P. 29.

The objectives of the national economic planning are the targets of the national interests Hence, the techniques of national economic project evaluation are more complicated than those adopted in the private enterprise system. Both direct and indirect effects of the project upon each objective of economic development have to be considered. Furthermore, the scarce resources have to be valued at their real costs, i.e. at the shadow prices of the factors of production. Direct effects and the value of resources used, at market prices, are quite sufficient for evaluation from the enterpreneur's point of view.

Before we deal with the application of the techniques of economic project evaluation, we shall discuss briefly the indirect effects of the project.

INDIRECT EFFECTS OF THE PROJECT :

Any project has two classes of effects, the direct effects and the indirect ones. The direct effects consist of the first ring in the chain of relationship which the project establishes (payment for inputs and sales of production). The indirect effects are the remaining links both backward and forward. As a rule, indirect effects will be found in the stages of production vertically

related to the new production, i.e. the stages preceding or succeeding the process involved.

In development planning, the project has to be looked at through all its relation, direct and indirect, to other economic activities. The measurement of both the direct and indirect effects is very important to estimate the total demand and supply of the project; either within the same sector or outside it. Furthermore, it determines the external economies[1] that would be created by the project and which will be included in the calculations of economic project evaluation.

Indirect effects may be calculated in either of two ways: by using the input/output analysis, or the method of the backward and forward links of the project.[2] The input/output analysis may be used directly to estimate the final effects resulting from the establishment of the project. In order to use such an approach definite data

---

(1) "External economics are invoked whenever the profits of one producer are affected by the actions of other producers. Expressed in function as $P_1 = G(x_1, l_1, c_1 \ldots\ldots; x_2, l_2, c_2)$ which shows that the profit of the firm depends not only on its output and factors inputs but also on the factor inputs of other firms. See, T. Scitovsky, "Two concepts of External Economics", The Economics of Underdevelopment, A.N. Agarwala and S.P. Singh, Oxford University Press 1958, p. 298.

(2) Manual on Economic Development Projects op. cit. p. 209.

and information are required. However, most under-developed countries are suffering from the shortage of such data, especially in the first stages of development planning.

The alternative to the input/ourput analysis, for measuring the indirect effects of the project is to make some kind of approximate estimates. These estimates could prove imperfect and not reflecting the complete magnitude of indirect effects of the project in question, but it is better to use them than to rely upon consideration of direct effects alone. These estimates depend on the project itself and the actual circumstances. The project's relation to other projects is considered in two ways: the backward, (which means towards the source), and the forward (that means toward the destination). Consider, for example, the case where the only objective of development is to increase production and national income.(1) It may be possible to estimate the direct effects, i.e. the value added created by the project,

---

(1) J. Tinbergen, The Appraisal of Investment Projects, The Semi-input/output Method, Memo No. 159 INP., Cairo, U.A.R. 1962, p. 3.

employment, "r" to a unit increase in foreign currency (earning or saving), then the total "valuation"[1] of project 1, say V_1 would be equal to

$$V_1 = a_1 P + b_1 q + c_1 r$$ and that of the alternative project 2, would be

$$V_2 = a_2 P + b_2 q + c_2 r$$

On the cost side, the major factor may be capital invested in the project K_1 , K_2 for project 1, 2 respectively. The various alternative projects will have a valuation V_1 , V_2 , etc., and those with the highest "yields" $\frac{V_1}{K_1}, \frac{V_2}{K_2}$ ..., should be taken first until the capital available for investment has been wholly exhausted.

Efficiency of the what program is measured by the fact that no projects that are excluded have a high productivity.

---

(1) The determination of weight of each objective by the Planner must be based on the study of the social Welfare. This valuation contains self-judgment but it must be based on economic and social studies of the economy, as far as possible.

The most accurate method of estimating the economic impact of any project would be to use a detailed econometric model bringing out all the relationship existing between the projects and the economy as a whole. Such models will be very complicated and can be used in few countries.

(II) ALTERNATIVE TECHNIQUES OF PROJECT EVALUATION BASED UPON THE APPLICATION OF PARTIAL CRITERIA

A) THE PROJECT'S EFFECTS ON THE NATIONAL INCOME

The main objective of most of underdeveloped countries is achieving a high rate of growth of national income. Accordingly, the development agency is responsible for selecting the projects which fulfil this objective, i.e. a certain criterion related to the national income has to be applied in order to establish the order of priority among projects. One such technique is the Discounted Cash Flow Return Method. It may be also called, the profitability index, investment method or internal rate of return method. This method deals mainly with computing :

(i) The total net earnings of the project during its life time.

(ii) The total time of disbursements and receipts[1]. The computation is based on the premise that cash in hand is worth more than cash to be realized in the future, therefore, cash to be received in the future years must be discounted.

---

(1) Financial Evaluation of capital Projects, U.N. Industrial Planning Course, INP, Cairo, U.A.R. 1965, P. 10.

> "Discounting is indispensable for all problems where the time shape and length ef the investment input and the output streams are significally variable"(1)

According to this method, the total net earnings of the project have to be reduced to a common base. One way is to express returns as the project internal rate of return(2). Since such a rate is independent of the absolute size of the project, this method provides a useful standard by which all types of alternative projects can be ranked. The minimum rate of return for the "marginal" project to be accepted, should be equal to the opportunity cost of capital and not to the rate of interest, since this would imply a perfectly elastic supply of funds at that rate. Furthermore, the rate of interest, in all probability, is fixed by monetary policy consideration and will not reflect the real cost of capital.

In order to determine the internal rate of return of a project, the net cash flows during the life time of the project has to be known. The internal rate of return is that rate of discount, which when applied to the stream of net cash flows

---

(1) F.M. Bator "On Capital Productivity, Input Allocation & Growth" American Economic Review, March 1961, P. 112, See H.J. Solomon Op. cit.,P. 29.

(2) Economists recognize in this the well-known Keynesian Concept of the marginal Efficiency of Capital.

will equate the present value of the project to its cost:

$$S = \sum_{t=1}^{n} \frac{Rt}{(1+i)^t}$$

where "S" is the cost of the project, and "R_t" is the net cash flow in year t). This equation can be solved in "i" : the internal rate of return for the project.

The following illustration represents the computation of the interpolated rate of return(1). The minus signs represent inflows (inputs) and the plus signs represent the outflows (output). Paying attention to the sign, we multiply each by a discount factor raised to the appropriate power, and sum. We keep raising the rate until we reach to a zero present value of net flows (internal rate of return of the project is the discounting factor at this point). When the present value is between negative and positive signs one can obtain an interpolated rate of return that is approximate.

---

(1) J.M. Solomon, Op. cit., P. 34.

Year	Cash Flow	Discounted Factors For 12 %	15 %	20 %
1	- 1000	. 8927	. 8696	. 8333
2	- 1000	. 7972	. 7561	. 6944
3	+ 2500	. 7117	. 6575	. 5786
		- 1689.9	- 1625.7	- 1527.7
		+ 1779.2	+ 1643.8	+ 1446.3
Present value of Total flow		+ 89.3	+ 18.1	- 81.2

The interpolated rate $= 15 + \frac{18.1}{18.1 + 81.2} \times 5$

$= 15.9$

It should be noted that the initial value tried was "guessed". The positive values at 15 % means that the rate of return is higher than 15 %. But at 20 % the present value is negative which means the discount factor is too high. The fact that the present value of the total flows is possitive at 15 % and negative at 20 % means that the "true" rate is in between and can be obtained by interpolation.

The internal rate of return can be applied directly for project evaluation from the enterpreneur view point rather than the social point of view. It considers only the profits that can be created by the project in terms of annual earnings. From the national income point of view we require other considerations to be included. The profit on capital invested is not the only factor in ranking the desirability of the project from the national view point, other real benefits of a project should be included. Profits for certain types of projects may be zero, but their benefits in terms of value added may be great.

Therefore, for economic planning we have to find some other index, more comprehensive; including the value added of the project direct and indirect. Furthermore, scarce resources should be valued at their appertunity cost to the economy.

The national gross rate of return can be defined as "the annual rate of return in terms of value added obtained per unit of input that the project required."(1) It is designed to measure the national benefits of a project over some time

---

(1) M.J. Solomon, Ibid., p. 63.

horizon. The application of the national gross rate of return requires that the physical flows of the project be converted into their real value terms to get the opportunity cost for the factors of production as well as output. Both direct and the indirect value added have to be considered. Direct value added can be measured directly from the project.(1) Indirect value added, for the practical limitation can be taken as the immediate backward and forward effects.

Backward value added will be attributed to the project investment only in so far as demand derived from the project can be satisfied without new investment, i.e. by utilizing the idle capacity. If, for example, a limestone quarry is producing at less than normal capacity owing to the lack of suitable market, then when a new source of demand is opened to it by the installation of an iron and steel plant, the basic capital for increased output in the limestone quarry already exists. Therefore, the new value added created in the limestone quarry can be largely ascribed to the steel project's investment. Now,

---

(1) Value added may be defined as the gross value of goods to be produced once the project is ready for operation, less the value of all material inputs.

looking at it from the forward indirect effects view point, the goods of the project in question are used as inputs in other enterprises which are not operating at fully utilized capacity. Establishing the project will enable the other enterprises to expand their output, with no additional investment.

It should be mentioned that not only the positive indirect value added (external economies) but also the negative indirect value added (external diseconomies) must be considered as net indirect effects of the project.

Thus the increase of national income due to the Project is : $N = P + (E - D)$

Where, "N" is the increment of national income due to the project; "P" is the direct value added to the project; "E" represents the positive indirect value added, external economies; and "D" is the negative value added; external diseconomies.

The following illustration shows how the national gross rate of return can be determined, taking into consideration different valuation (shadow prices) for the foreign exchange; in order to show the importance of factors of production's valuation in deciding desirability of the project.

Year	Total Flow	Foreign Exchange Flow	20% x Col.2 Penalty 20%	Col.1 + col.3 Total flow with 20% foreign exch. Penalty	Col.4 + col.3 Total flow with 40% foreign exchange Penalty
	1	2	3	4	5
1	- 1000	- 500	- 100	- 1100	- 1200
2	+ 1200	+ 300	+ 60	+ 1260	+ 1320
Rate of Return	20%			14.5 %	10 %

In year one, the total inflow is input of $ 1000, this includes $ 500 of foreign exchange. In year two, the total flow is $ 1200 with $ 300 of it being foreign exchange. If the foreign exchange price is the equilibrium price, the national gross rate of return will be 20 %. If it is not, and the equilibrium rate at 20 % penalty(1), the rate of return will be 14.5 %, and 10 % at 40 % foreign exchange penalty.

(1) M.J. Solomon, has suggested what is called foreign exchange penalties. By penalty of e.g. 20 % is meant that each unit of foreign exchange expenditure is valued at 20 % above the official rate of exchange, and for each unit earned or saved a "premium" of 20% above the official rate of return. See M.J. Solomon, Op. cit. p. 65.

This criterion, however, even when corrected for the "indirect effects", fails to take account of the project's contribution to the other objectives (employment and balance of payments). Of course, if one assumes that there exists one production function for each project, maximum output will imply maximum employment. However, as long as the choice of technique is open to the planner, either via the choice of technology or via choice among alternatives projects with substitutable outputs; maximum output, employment, and foreign exchange earned or saved will not be satisfied simultaneously.

- - - - - - -

(B) PROJECT'S EFFECTS ON THE BALANCE OF PAYMENT

Another partial criterion which can be used to establish the order of priority among projects, is the foreign exchange criterion. This criterion can be applied directly when the main objective of development is realizing equilibrium of the balance of payments. Therefore, a great emphasis is placed on selecting projects which have a large positive effect on the balance of payments.

THE FOREIGN EXCHANGE CRITERION

The effects of the project on the balance of Payments is two fold[1]: first, the foreign funds needed to carry the project through; this means, the effects of the project's installation and operation on imports - the negative effect. Secondly, the foreign funds earned or saved as a result of the project: the foreign currency created by import substitution or increased exports. The net effect of the project upon the balance of payments will be the difference between the positive and the negative effects.

---

(1) Formulation and Economic Appraisal of Development Projects U.N. Vol. 1, P. 453.

THE EFFECTS ON IMPORTS :

Imports will directly increase to the extent that the project has to import foreign capital goods such as equipment tools, etc., needed in the period of installation as well as raw materials and semi-finished goods, needed during the project's operations.

Possible effects of the project such as reducing imports, must also be considered, if the project is going to produce food or other products now being imported, or which otherwise would have to be imported in the years ahead .

THE EFFECTS ON EXPORT :

Many projects, especially agricultural, will expand the production of exportable commodities. In order to estimate the possible increase earned from increased exports, we need to estimate how large the possible export value would be. This involves considering the economic situation and outlook for the export products, as well as a reasonable assumption on the prices at which these products might sell in the future.(1)

---

(1) Ibid p. 454.

There are two types of evaluation coefficients concerning foreign exchange[1]; each of them can be used directly according to the available data - for establishing priorities among alternative projects, when the only objective is the balance of payment. The numerator of the coefficient represents the favourable effect, while the denominator represents the unfavourable effect. The first one is obtained by dividing the net annual foreign exchange - difference between the positive and negative effect - by the foreign exchange component of investment, the result being a sort of production/capital ratio, referring only to the foreign currency in question. It would 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 available per unit of complex of inputs factors which the project requires in foreign currency; i.e. the productivity of foreign currency used in the investment, as well as the operation process. It may be called output/input ratio, in terms of foreign currency, taking into consideration the life-time of the project.

---

(1) Manual on Economic Development Projects, Op. cit., P. 230.

For the purpose of evaluation, present worth must be calculated for the annual negative effect and added to the foreign exchange in the original investment, which represents the denominator of the coefficient. While the numerator is the present worth of positive effect - total foreign exchange earned or saved. In this respect, rate of interest of foreign currency will have to be decided upon the average profitability of foreign, public and private, capital invested in the economy.

In this respect, it is important to mention that an evaluation in terms of foreign exchange, may provide important background data, but it should not be regarded as the only criterion for deciding priorities among projects. Its importance derives from the frequent scarcity of exchange in underdeveloped countries.

(C) PROJECT'S EFFECTS ON EMPLOYMENT

A high level of employment is considered an important objective for populated underdeveloped countries with unemployment and a low standard of living. Therefore, the selected projects must contribute in solving the problem of unemployment.

The project's contribution in solving the unemployment problem depends mainly upon the nature of the project and the technology adopted. In that case, it is obvious that, the employment criterion will have a great role in drawing the investment policy towards labour intensive projects.

Employment per unit of Capital Criterion

Priorities among projects can be established according to the application of employment coefficient. This coefficient is obtained by dividing the number of persons employed in the project by the latter's total capital requirements.(1) Shadow prices of labour have to be used in the calculation, while the market prices are important only for the purpose of the project's financing.

---

(1) For more details, See Manual on Economic Development Projects op.cit., p. 223.

According to this criterion, the project employing the greatest number of persons per unit of capital at the accounting prices, will have a higher priority, because it realizes the maximum contribution to solving the problem of unemployment.

The numerator of the coefficient which represents the employment created by the project does not only consist of the direct labour employed by the project, primary employment, but also of the indirect labour - secondary employment - created in the other economic activities, as a result of the project's establishment. These secondary effects were formally analysed for the first time by R.F. Kahn[1] when he presented his theory of the employment multiplier, the ratio between the increment of the total employment and the increment of the primary employment. The total employment includes the primary employment, plus the secondary employment. In formula

$$M_t \cdot E_1 = E$$

where :

E = total employment

E_1 = primary employment

M_t = employment multiplier

(1) R.F. Kahn "The relation of Home Investment to Unemployment Economic Jornal, June 1939,
The first idea of the multiplier and its principle was discussed by Keynes in an essay entitled, Lioyd George Doits. This essay was published before Kahn's theory, see the General Theory of Keynes by Dr. G. Said, Cairo, UAR, p. 136

As a matter of fact, inspite of the practical and conceptual difficulties of estimating the secondary effect of the project upon the employment, it may be very important, especially in case of general unemployment.

The indirect employment of labour may be measured either backwards or forwards with respect to the project; in this respect, immediate backward and forward only, can be measured. If employment per unit of capital is measured as a direct effect, and derived employment is recognized as an indirect benefit, the investment required for such a derived employment must be estimated. If there is an unutilized capacity in the derived activities, no new investment will take place; the whole extra employment may be atributed to the project.

Input - output table may be used when data and information are available. It enables the quantitative estimation to be made of direct and indirect employment of labour.

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, and could be adopted for the establishment of a definitive order of priority.(1)

(1) Manual on Economic Development Projects op.cit., p. 224.

(D) FINAL ESTABLISHING OF PRIORITIES

According to the partial criteria, those criteria related to the productivity of a single factor of production the order of priority among projects may be established. Each project has different effects upon each objective of development. One project may create a high percentage of value added, but at the same time its contribution in solving the problem of unemployment is very low. Another alternative project may earn or save a little amount of foreign currency but may have a strong effect upon employment. These conflicts create a certain problem to the planner : for how can he select the projects which give maximum contribution to the objectives of development ? The application of the partial criteria separately may be valid only under certain corditions[1] :

(i) Other considerations being equal, the effects on the employment and the balance of payments, preference will be given to a project that will make per unit of scarce resource expended the highest contribution to the national income.

---

(1) El-Tigi A.S., Towards a system for determining Industrial Priorities, Memo N° 545, Feb. 1956 INP. Cairo, U.A.R., p. 5.

(ii) Other considerations being equal, preference will be given to a project that will give, per unit of scarce resources expended, the highest measure of improvement in the country's balance of payments position.

(iii) Other considerations being equal priority will be assigned to a project that will make the most use of domestic labour.

Practically, it is almost impossible that these conditions could be satisfied. Therefore, the establishment of priorities among projects, from the planning point of view, under the assumption of more than one objective, requires another method to be applied. It may be possible to make some adjustment to the partial criteria in order to include all the effects of the project in the numerator of the evaluation coefficient; given valuation (weights) to the objectives of economic development.

This valuation may be chosen intuitively to begin with; it should reflect what, in the planner's mind, a unit increase in each target means to the nation. For instance, if project 1 will yield an increase of a_1 , b_1 , c_1 , (an increase "A" in national product; an increase "B" in employment, an increase "C" in foreign exchange earning of saving) and project 2: a_2 , b_2 , c_2 and the valuation given to the various targets are, say 'P' to a unit increase in national product, "q" to a unit increase in

employment, "r" to a unit increase in foreign currency (earning or saving), then the total "Valuation"[1] of project 1, say V_1 would be equal to

$$V_1 = a_1P + b_1q + C_1r \text{ and}$$

that of the alternative project 2, would be

$$V_2 = a_2P + b_2q + C_2r$$

Evidently, the values of P, q, r are relative that is: 'p' could be taken as equal to 1, upon the choice made for q, r

On the cost side, the major factor may be capital invested in the project K_1 , K_2 for project 1, 2 respectively. The verious alternative projects will have a valuation V_1 , V_2 etc., and those with the highest "yields" $\frac{V_1}{K_1}$, $\frac{V_2}{K_2}$ ..., should be taken first, until the capital available for investment nas been wholly exhausted . Efficiency of the whole program is measured by the fact that no projects that are excluded have a nigher productivity

---

(1) The determination of valuation (weight) of each objective by the planner must be based on the study of the social welfare. May be this valuation contains self-judgment but if must be based on economic and social studies of the econony, as far as possible.

of investment, than any project is included. A numerical example may illustrate the points made.(1)

The absolute targets for the economy as a whole may be :

A	: the increase in national product	:	$ 1,000 million;
B	: the increase in employment	:	1 million persons
$C_{(x)}$	: the increase in foreign exchange	:	(earning or saving) $ 200 million.
D	: the increase in life expectency	:	1 year.

For industrial projects 1 and 2, the results obtained are

a_1	= $ 1 million	a_2	= $ 800,000
b_1	= 500 persons	b_2	= 1000 persons
c_1	= $ 200,000	c_2	= $ 100.000
d_1	= 0	d_2	= 0

when an increase in income of $ 1 million is considered of the same value as an increase in employment of 500 persons or an increase in foreign exchange of 0.1 million; i.e. the valuation system

$$p = q = r = \frac{1}{\$\ 1 \text{ million}} = \frac{1}{500 \text{ persons}} = \frac{1}{\$\ 0.1 \text{ million}}$$

---

(1) E.C.A.F.E, Development programming Technique Series N° 1, Programming Techniques for Economic Development, P. 36. U.N., Bangkok 1960.

(x) not included in the example.

For the objectives, income, employment and foreign exchange, the valuation[1] of project 1 would be

$V_1 = 1 + 1 + 2 = 4$, and that of project 2

$V_2 = 0.8 + 2 + 1 = 3.8$

Furthermore, the costs involved in both projects are capital invested: K_1 = $ 1.5 million, and K_2 = $ 1.2 million.

This numerical example shows values of these yields of respectively $\frac{4}{1.5}$ and $\frac{3.8}{1.2}$: 2.6 and 3.1 for project 1 and 2.

According to this method of priorities, the planner selects a certain set of projects which fulfill the objectives of economic development, (fixed in advance), within the limits of available resources.

Partial analysis technique is a method used for establishing priorities among projects, but it is not the best one that can be applied to solve the problem of project

---

(1) It will be understood that there is a difference in the nature of prices, the prices of aims and the prices of factors of production; the former can be autonomously determined by the policy maker, but the latter must reflect the relative scarcities of the scarce factors of production, i.e. the accounting prices. See, J. Tinbergen, The appraisal of investment project. December 1963 INP. Cairo, U.A.R. p.6.

evaluation. The application of any one of the partial criteria will not lead to the selection of the project which gives maximum contribution to the objectives of development, because each of them is concerned with one objectives and one scarce factor of production. Even, when the effects of the project upon the objectives of development have been measured as the numerator of the evaluation coefficient, the denominator is only capital. Capital is not the only scarce factor of production, it may be more than one factor of production such as : the availability of foreign exchange, skilled labour, natural resources or any particular commodity. Another problem is concerned with the price, i.e. the difficulties of the number of corrections and modifications that have to be applied to market prices to arrive to the real values. The series of successive approximation of accounting prices may will be helpful but it is not a substitute for an overall and simultaneous price solution. For example, in measuring the value of output it is possible to take into account the more obvious defects in prices due to the direct effects of the tarrifs, indirect taxes and subsides, but it is difficult to consider all their indirect effects. Furthermore, the effects of interdependence cannot be included readily in the partial analysis :

The partial analysis technique can be applied in most of underdeveloped countries when data and information are in shortage. Nevertheless, it would ultimately remain a second best solution.

The optimum solution of the resource allocation may be based upon the application of the comprehensive analysis technique. This can be provided within the context of linear programming, in which the conditions of consistency and efficiency are satisfied in a systematic way.

CHAPTER V

LINEAR PROGRAMMING TECHNIQUE

LINEAR PROGRAMMING

(I) Concept :

Linear programming[1] is a mathematical technique dealing with the optimal solution to problems. It has been applied to a wide range of problems facing the firm in decision making. Dantzig summarizes the using of Linear Programming technique in the industrial field as follows[2] : first, it has provided a novel view of operations; second, it induces research in the mathematical analysis of the structure of industrial systems; and third, it has become an important tool for business and industrial management for improving the efficiency of these operations.

---

(1) Linear Programming is a branch from the Linear economics which was developed by G.B. Dantzig in 1947 as a technique for planning the diversified activities of the U.S. Air Force. G.B. Dantzig, "Maximization of the Linear Function of Variables Subject to Linear Inqualities" in T.C. Koopmans (ed.). Activity Analysis of production and Allocation, pp. 339-347, Jhon & Sons, INC., N.Y. 1961.

(2) G.B. Dantzig, Linear Programming and Economic Analysis McGraw-Hill Book Company, INC., N.Y. 1958, p. 28.

Important characteristics of Linear Programming may be summarized as follows[1]:

(i) The most common element for Linear Programming to be applied is the searching of the "best" values for the decision variables.

(ii) The "best" values of the variables have to satisfy a certain number of inequality constraints.

(iii) In most cases, especially in economics, variables have to be limited to non-negative values.

(iv) Programming, is the mathematical method for the analysis and computation of optimum decision which doesnot violate the limitation imposed by inequality side - conditions. In almost all cases the method of computation is the so-called iterative procedure.

(v) Where the problem is one involving linear programming problem, there are several computational methods which yield a precise answer after a finite number of steps.

---

(1) W.J. Baumol, Economic Theory and Operation Analysis 1961 op. cit., pp. 68-70.

The simplex method[1], and the complete description method are some of these techniques.

The Linear Programming problems always come in pairs, in the sense that, two problems are related to each other. If one of them is solved the other will be solved also. It may be considered that the problem of resource allocation as well as the problem of price are two aspects of one linear programming problem. An economist would expect that since linear programming solves the problem of resource allocation, it would solve the problem of price also, and this is what the dualism property consists of.

---

(1) The simplex method is always suggested to solve the linear programming problem, the name was not chosen to imply that the procedure is simple. Roughly, a simplex may be described as the N- dimensional analogue of a triangle. The outline of the computation indicates that the method consists of successive investigation of adjacent corners of a figure which can be broken up into a series of simplexes. For more details of the algorithm of the simplex method see. G.B. Dantzig, Linear Programming and Extension, Princeton University Press, N.J., 1963., p. 84 also, Dorfman, Samuelson and Solow, op. cit., p. 74.

(II) Mathematical Linear Programming Technique

The mathematical definition of linear programming is "the analysis of the problems in which a linear function of a number of variables is to be maximized or minimized subject to a number of restraints in the form of Linear inequalities"[1].

The mathematical linear programming problem consists of three parts (i) the preference function whose value is to be maximized or minimized. (ii) the constraints, and (iii) the non negativity conditions on the variables.

The set of inequalities "m", in "n" variables may be given as follows :

$$\begin{aligned} a_{11} x_1 + a_{12} x_2 + a_{13} x_3 + \ldots\ldots + a_{1n} x_n &\leqslant b_1 \\ a_{21} x_1 + a_{22} x_2 + a_{23} x_3 + \ldots\ldots + a_{2n} x_n &\leqslant b_2 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots & \\ a_{m1} x_1 + a_{m2} x_2 + a_{m3} x_3 + \ldots\ldots + a_{mn} x_n &\leqslant b_m \end{aligned} \qquad 5.1$$

The equations may be written as :

$$\sum_{J=1}^{n} a_{ij} x_j \leqslant b_i \qquad (i = 1, 2, \ldots, m) \qquad 5.2$$

---

(1) W.J. Baumol, Economic Theory and Operation Analysis 1961 op.cit, P. 70.

We seek values of the variables x_j satisfying the previous constraints and,

$$x_j \geqslant 0 \qquad (j = 1, 2, 3, \ldots, n) \qquad 5.3$$

The optimum solution, consists of the values of x_j which maximize (or minimize) some linear preference function :

$$Z = \sum_{j=1}^{n} c_j x_j \qquad 5.4$$

The technical coefficient a_{ij} and b_i and c_j are assumed to be known constants. In order to convert the inequalities to equalities we have to use what is called slack variables; since:

$$\sum_{j=1}^{n} a_{ij} x_j \leqslant b_i \qquad (i = 1, 2, \ldots, n)$$

is equivalent to :

$$\sum_{j=1}^{n} a_{ij} x_j + x_{n+1} = b_i \qquad 5.5$$

where

x_{n+1} is a non-negative slack variable

Also,

$$\sum_{J=1}^{n} a_{ij} x_j \geqslant b_i \quad (i = 1, 2, 3 \ldots, n) \qquad 5.6$$

is equivalent to :

$$\sum_{J=1}^{n} a_{ij} x_j - x_{n+1} = b_i \quad (i = 1, 2, 3, \ldots, n) \qquad 5.7$$

with the condition that, $x_{n+1} \geqslant 0$

There is always an optimal solution for any linear programming problem in which the total number of non-zero variables of both kinds (ordinary x_1 , x_2 , ..., x_n and the slack variables) is exactly equal to the number of capacity limitation.

We can also construct a different problem by rearranging the data of the problem just stated. Condition (5.1) consists of "m" inequalities. First, we introduce a variable to correspond to each of the inequalities and call the new variables u_1 , u_2 , ..., u_m . Then we form the sum of the cross products of these new variables with the constants on the right-hand side of the inequalities, i.e we form(1)

$$Z = b_1 u_1 + b_2 u_2 + \ldots + b_m u_m \qquad 5.9$$

(1) Dorfman, Samuelson and Solow, Linear Programming and Economic Analysis, op.cit. P.40

Next we form an inequality involving the U's to correspond to each of the variables x, in the original problem, using for that purpose the coefficients of the x's in the original problem. For example, by using the coefficients of x_1 in the original problem we derive the inequality.

$$a_{11} u_1 + a_{21} u_2 + \dots + a_{m1} u_m \geqslant c_1$$

Note that we have reversed the inequality sign. Next we pick up the coefficients of x_2 in the original problem and cross-multiply them with the u's to obtain the second dual constraint. Continuing in this way we derive the whole set of dual inequalities.

$$\begin{aligned}
&a_{11} u_1 + a_{21} u_2 + \dots + a_{m1} u_m \geqslant c_1 \\
&a_{12} u_1 + a_{22} u_2 + \dots + a_{m2} u_m \geqslant c_2 \qquad 5.10 \\
&\dots\dots\dots\dots\dots\dots\dots \\
&a_{1n} u_1 + a_{2n} u_2 + \dots + a_{mn} u_m \geqslant c_n
\end{aligned}$$

We then consider the problem of finding a non-negative set of values, $u_1, u_2, \dots, u_m$ which makes expression (5.9) as small as possible and satisfies the inequalities (5.10). This is another linear programming problem, called the "dual" of the problem involving the x's.

(III) Application of Linear Programming Technique

The purpose of economic project evaluation in development planning is to find a set of projects which would give maximum contribution to the objectives of the development plan within the limits of available resources. This problem, is compatible with the problem of linear programming, i.e., to maximize the value of a linear objective function subject to linear constraints. Accordingly, the linear programming technique, as a comprehensive analysis technique, can be used directly to determine the optimal projects programme.

This technique is related mainly, to what is called the optimal planning approach, in the sense that, the planning has to achieve as much as possible values to the objectives of development.

---

(1) Frisch is one of the strongest advocates of the use of linear programming for development planning, as indicated in the preference to recent methodological study. "In the beginning of 1959, during my work as a United Nations expert in Cairo I was confronted with the problem of working out a methodology for optimal development programming in a rapidly expanding underdeveloped country. I have always believed - and my Cairo experience have confirmed it - that such a method must be formulated interms which ultimately make the problem amenable to linear programming. Otherwise, one is practically certain to be taken by surprise afterwards in unexpected balance of payments difficulties and other troubles". R. Frisch, powerful Method of Approximation in Optimum Investment Computation of the Normal Oslo (1959) (Mimeo) p. 11. See, H.B. Chenery, American Economic Review op. cit. p. 33.

The solution of the linear programming problem, in addition to providing the optimal consistent programme of production, yields the following additional information :

(i) The value of marginal products of the scarce factors of production.

(ii) An estimate of the amount of unemployment of different factors associated with the optimal production plan.

We must keep in mind, however, that linear models assume competitive market or fixed input and output prices; and constant returns to scale in production.

It is possible to formulate the economic project evaluation problem in a general form of linear programming in the following manner, suppose the limited resources of "K" different types are available in quantities S_1 , S_2 , S_3 ..... , S_k .

There are 'N' possible activities A_1 , A_2 ..., A_n whose net returns per unit are V_1 , V_2 , ... , V_n . A production program is specified by a set of production activities x_1 , x_2 , x_3 ....., x_n which present output per unit of project one, two up to n. which fulfill the following requirements.

No activity level is negative, i.e.

$$x_1 \geq 0 , \quad x_2 \geq 0, \ldots\ldots, x_n \geq 0 \qquad 5.11$$

No more than the available supply of any resource is required, for example if, S_1 is capital, S_2 is foreign exchange, S_3 is skilled labour and S_4 is unskilled labour, the following constraints have to be satisfied :

$$\begin{aligned} a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + \ldots + a_{1n}X_n &\leqslant S_1 \\ a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + \ldots + a_{2n}X_n &\leqslant S_2 \end{aligned} \qquad 5.12$$

$$\begin{aligned} a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + \ldots + a_{3n}X_n &\leqslant S_3 \\ a_{41}X_1 + a_{42}X_2 + a_{43}X_3 + \ldots + a_{4n}X_n &\leqslant S_4 \end{aligned}$$

where a_{ij} is the number of units of the j^{th} resource used to produce one unit of output by i^{th} activity. The allocation problem is simply to find a programme vector x that satisfy the requirements 5.11 and 5.12 and makes "r" the total returnes as great as possible.

$$r = V_1X_1 + V_2X_2 + \ldots\ldots\ldots + V_nX_n \qquad 5.13$$

where V_i represents the effects of a unit of project i upon the objectives of development weighted by the planner.

In order to form the problem of price as a second aspect of the original problem, we have to rearrange the data of condition 5.12 and introduce new variables U_1 , U_2 , U_3 and U_4 which represent the equilibrium prices of the factors of production.

$$0 \leqslant u_1 \ , \quad 0 \leqslant u_2 \ , \quad 0 \leqslant u_3 \ , \quad 0 \leqslant u_4 \qquad 5.14$$

The imputed value of the resources must be either positive or zero. Economically, this reflects the facts that as long as we assume the possibility of costless idsposal, no resources can have negative values.

If we select any set of "N" activities we can choose the prices of the fixed factors of production, so that in each activity of the set, the imputed cost of the resources required by a unit of the activity, calculated from these prices, is equal to the net returns of a unit of activity. If the set of 'N' activities selected is an optimal set, then, as we have just seen, the set of prices u_1, u_2, u_3, u_4 will satisfy requirement 5.14 and the simplex criterian will show that for each activity not in the optimal set the imputed cost of the resources observed will be at least as great as the unit net returns.

This linear programming problem can be solved mathematically, by the simplex method , the results of which will be as follows :

(i) The best set of projects which give maximum contribution to the objectives of development within the limits of available resources.

(ii) The output of this set of projects represent the optimal production program.

(iii) The shadow price for each factor of production.

The linear programming technique as a method of economic project evaluation satisfies the conditions of efficiency as well as consistency. Efficiency in the sense that, no projects outside the program is more productive than any one within the programme. Consistency conditions refers to balancing between demand and supply for commodities as well as factors of production.

Therefore, linear programming technique is suggested for economic project evaluation in the course of formulating the development planning, provided that, data and information on the level of the economy are available.

CHAPTER VI

AN APPLIED STUDY OF ECONOMIC PROJECT EVALUATION

In this chapter we present an applied study of economic project evaluation using linear programming techniques. It is not an overall study, in the sense that, the projects will not be evaluated in the context of the entire economy. It is a study on the level of one industrial branch (Metallurgical Industrial Branch) of the industrial sector in the U.A.R. The problem here, is that of establishing priorities among project proposals under certain fixed constraints such as capital and foreign exchange. We suggest a method which can be applied, and give an example of its application, as a case study.

Two methods can be applied, the first, is the ideal one, in the sense that, it is consistent with all the considerations which we have pointed out in the preceding chapters. According to this method, projects will be evaluated within the context of the economy as a whole. The direct and indirect effects have to be considered. Furthermore factors of production and output will be valued at their real costs. Accordingly any project which shows a positive net return over costs (including capital costs) should be approved, and the ranking can be established according to the size of the rate of return.

Such a method would require an estimation of the set of shadow prices for all primary factors of production and intermediate goods. Since the formulation of linear programming model for the economy, at such detailed level as to yield the set of prices, is beyond the scope of this study, we chose not to follow this approach.

The second approach may be applied in the case when data and information are incomplete at the desired level of disaggregation for the entire economy. For the industrial branch under study, no data or information concerning the indirect effects nor the equilibrium prices are available. Therefore, given the available data, we have to construct a certain method for project evaluation neglecting the indirect effects. We might be partially justified by the fact that in the branch considered, metallurgical industries, externalities are judged small on a priori grounds. Fixed prices of the factors of production and commodities will be used for the valuation rather than shadow prices.

A method for Assigning Priorities :

We considered the objectives of development as the maximization of some linear function of national income, employment and the net positive effect on the balance of payments. These objectives have to be weighted by the planner, the weights should express the relative importance of the alternative goals in the social utility function.

Let "v_i" stand for the value added created per unit of output of project "i"; "e_i" stand for employment, in terms of wages,(1) created per unit of output of project "i"; "b_i" the project's net effect on the balance of payments created per unit of output of project "i". The weights of each unit of objectives are P_V , P_E and P_B.

The objective function, therefore, will take the form :

$$R = (V_1P_V + e_1P_E + b_1P_B)X_1 + (V_2P_V + e_2P_E + b_2P_B)X_2 + \ldots$$
$$\ldots\ldots + (V_nP_V + e_nP_E + b_n P_B) X_n \qquad 6.1$$

Where the proposed projects are A_1 , A_2 , ... , A_n , and "X_i" represents unit of output in project "i".

---

(1) Wages are fixed by the government, therefore, the wages bill and employment are linearly correlated.

Let the term $(V_i P_V + e_i P_E + b_i P_B)$, the contribution of one unit of X_i to the objectives of development by project "i" be represented by "W_i" .

$$R = \sum_{i=1}^{n} W_i X_i \qquad 6.2$$

The objective function in question has to be maximized subject to two constraints: domestic capital and foreign exchange. It may be possible to add any other constraints such as skilled labour, unskilled labour, land, etc. The technical coefficient for each project were calculated, i.e. the amount of capital and foreign exchange required to produce one unit of output in each project. If we consider that in project "i" the capital technical coefficient is "k_i", and for the foreign exchange is "f_i" , the constraints take the form :

$$\left.\begin{aligned} \sum_{i=1}^{n} k_i x_i &\leqslant K \\ \sum_{i=1}^{n} f_i x_i &\leqslant F \end{aligned}\right\} \qquad 6.3$$

The solution to the problem is to find the number of x_i's that satisfy the requirement 6.3, and make "R" the objective function as great as possible provided that :

$$x_1 \geqslant 0 , \quad x_2 \geqslant 0 , \ldots , x_n \geqslant 0$$

Linear programming algorithms[1] are available for the solution of such a problem. However, the simplex algorithm will normally give the solution values for x_i's , given the values of constraints K and F, with no indications about the ranking of the projects.

To rank the projects, we adopted the following technique, which is based on the properties of the solution method, and the nature of the problem.

1) If the constraints K and F were chosen small enough, only the best project or projects will be chosen in the solution, leaving out of the solution a majority of projects.

2) Since all the functions involved are linear, any project which is selected in the solution will enter with its full capacity: i.e., if project "i" is chosen in the solution, x_i will be equal to its upper bound (maximum output). The exception to this rule is the project which is chosen as the last project, whose output might be limited by running out of K and F.

---

(1) See the FORTRAN Computer Program, R. Amer, Basic Principles in Linear Programming, Memo. No. 483, pp. 49 - 60, INP. 1964, Cairo, U.A.R.

3) If we relax the K and F constraints a little at each successive step, new projects will enter the solution at each successive step. In this way priority can be assigned to each project or group of projects depending on the magnitude of the steps taken in relaxing the K and F constraints with the order of priority conforming to the order of entrance in the solution.

4) An exception to this method of ranking should be made when at any step, the entrance of project "i" in the solution excludes project "h" which has entered at some preceding stage, from the solution. This would happen if project "i" was superior to "h", however, the K and F constraints were too tight to admit it at a preceeding stage. In such a case, project "i" should get the order of priority previously assigned to "h" and "h" would wait till it enters.

5) From step (2), we can avoid obtaining nonsensical solutions of the form: put all K and F in project j, we can add a set of upper bounds on the outputs x_i representing the maximum output of each proposed

project. This is one way to handle the problem of constant return to scale, which could have been also handled by the use of integrer programming.

6. Since we are considering this group of projects in isolation, a check on the consistency of the solution is the fact that until all the projects with positive contribution to the objective function are included in the solution, the slack in both K and F should be zero at each step.

The Data :

The data are given in the Appendix. They cover thirty projects in the metallurgical branch of industry. For each proposed project, the following data are given :

1) The local capital currency.
2) The foreign exchange requirements.*
3) Production in quantity and value.
4) Value added.
5) Value of imported materials.
6) Exports in quantity and value.
7) Employment in number and wages.

---

* Foreign exchange valued in Egyptian Pounds.

In using these data for ranking the projects, the following assumptions had to be made for the lack of further information :

1) Since the life span of the project is not given, we assumed that all proposed projects had the same life span, and therefore our results could not be used as a policy guide unless this assumption is verified.

2) The output figures given will be assumed to represent the actual output during the life span of the project. One would have more confidence in the results had the time profile of output been available for each project, such that discounted flows could be used. But given the available data, both outputs and inputs for each project are considered to have a horizontal profile over time, and in the absence of any information on the life spans of individual projects, getting the present value would be both useless and meaningless.

3) The data on exports will be assumed to represent a constant flow of exports, at constant value, overtime. Although this assumption is highly untenable, one is forced to make it. Improvements on the results reported could be achieved by a careful study of future export markets.

The Results :

The choice of the set of weights to be attached to the different targets of the development is usually left to the planner. In the results reported below we used the set of weights $P_V = P_E = P_B = 1$, as a neutral choice. The calculations could be repeated for any desired set of weights, and the ordering of projects will vary with the choice of weights. We have not tried different sets of weights because of the limitations of electronic computer-time available to us. The objective function, using this set of weights is

$$R = (.0433)\,x_1 + (.0198)\,x_2 + (.0133)\,x_3 + (.0228)\,x_4 + (.0111)\,x_5 + (.0021)\,x_6 + (.0716)\,x_7 + (.0716)\,x_8 + (2.0500)x_9 + (.0033)\,x_{10} + (.0002)x_{11} + (.0613)x_{12} + (2.9500)x_{13} + (.0463)\,x_{14} + (.1480)x_{15} + (.1272)x_{16} + (.0686)\,x_{17} + (.2083)\,x_{18} + (.0558)x_{19} + (.1695)x_{20} + (.4705)\,x_{21} + (.0405)\,x_{22} + (.0392)x_{23} + (.0490)x_{24} + (.0833)\,x_{25} + (.0566)\,x_{26} + (.4972)x_{27} + (.0814)x_{28} - (.0213)\,x_{29} - (.0954)\,x_{30}\,.$$

The constraints took the form :

1) $(.0425)\,x_1 + (.0230)\,x_2 + (.0038)\,x_3 + (.0080)\,x_4 +$
$(.0261)\,x_5 + (.0046)\,x_6 + (.0294)\,x_7 + (.1559)\,x_8 +$
$(1.1050)x_9 + (.0733)\,x_{10} + (.0030)x_{11} + (.0127)x_{12} +$
$(1.8000)x_{13} + (.0171)\,x_{14} + (.0900)x_{15} + (.0297)x_{16} +$
$(.0683)\,x_{17} + (.0333)\,x_{18} + (.0297)x_{19} + (.1129)x_{20} +$
$(.2395)\,x_{21} + (.0166)\,x_{22} + (.0302)x_{23} + (.0297)x_{24} +$
$(.1326)\,x_{25} + (.0791)\,x_{26} + (.0581)x_{27} + (.0300)x_{28} +$
$(.1380)\,x_{29} + (.0293)\,x_{30} \leqslant K$

2) $(.0525)\,x_1 + (.0519)\,x_2 + (.0095)\,x_3 + (.0178)\,x_4 +$
$(.9192)\,x_5 + (.0069)\,x_6 + (.1021)\,x_7 + (.5516)\,x_8 +$
$(3.4200)x_9 + (.5050)\,x_{10} + (.0049)\,x_{11} + (.0498)\,x_{12} +$
$(4.3100)x_{13} + (.0770)\,x_{14} + (.1000)\,x_{15} + (.1995)\,x_{16} +$
$(.1503)\,x_{17} + (.2250)\,x_{18} + (.0460)\,x_{19} + (.2667)\,x_{20} +$
$(.2985)\,x_{21} + (.0114)\,x_{22} + (.0772)\,x_{23} + (.0906)\,x_{24} +$
$(.2453)\,x_{25} + (.2784)\,x_{26} + (.3088)\,x_{27} + (.1500)\,x_{28} +$
$(.3333)\,x_{29} + (.0393)\,x_{30} \leqslant F$

And the set of thirty upper bounds, stating that output of project "1" cannot exceed the output figure of Table (1) in

the Appendix. For technical reasons concerning the algorithm used, the problem had to contain at least one lower bound, so we imposed an artificial lower bound on x_1 : $x_1 \geqslant 10$ units.

It is worth noting that in the objective function, the variables x_{29} and x_{30} appear with negative signs. This is a result of the set of weights used, it gives net foreign exchange earnings the same weight as value added or employment. Each of these two projects is a net importer, with the value of imports exceeding the sum of value added and wages per unit. This will, fortunately, provide us with a second check on the consistency of the programme, since under no condition should either project appear in the solution.

The ranking was obtained by solving the problem on nine steps[1], increasing both K and F at each step. The results (the projectschosen) appear in Table (1) below :

Table (I)

Projects Included in each of The Nine Steps of The Solution

In millions L.E.

Project No.	(1) K=2.5 F= 5	(2) K= 5 F=10	(3) K=7.5 F= 15	(4) K=10 F=20	(5) K=15 F=30	(6) K=20 F=40	(7) K=30 F=60	(8) K=45 F=90	(9) K= 55 F=102.7
1								x	x
2									x
3	x	x	x	x	x	x	x	x	x
4	x	x	x	x	x	x	x	x	x
5									x
6									x
7			x	x	x	x	x	x	x
8									x
9				x	x	x	x	x	x
10									x
11									x
12		x	x	x	x	x	x	x	x
13				x	x	x	x	x	x
14				x	x	x	x	x	x
15	x	x	x	x	x				

(1) See Table No. II in the Appendix.

Project No.	(1) K=2.5 F= 5	(2) K= 5 F=10	(3) K=7.5 F= 15	(4) K=10 F=20	(5) K=15 F=30	(6) K=20 F=40	(7) K=30 F=60	(8) K=45 F=90	(9) K= 55 F=102.7
16			x	x	x	x	x	x	x
17								x	x
18		x	x	x	x	x	x	x	x
19		x	x	x	x	x	x	x	x
20				x	x	x	x	x	x
21	x	x	x	x	x	x	x	x	x
22	x	x	x	x	x	x	x	x	x
23					x	x	x	x	x
24					x	x	x	x	x
25									x
26									x
27	x	x	x	x	x	x	x	x	x
28				x	x	x	x	x	x
29									
30									

Some remarks on these results are in order :

(1) In each step, the value of the slacks in K and F were zero, as expected, except in the last step, where the slacks were positive. This is due to the fact that any additional capital or foreign exchange would better be left unutilized than used

in projects 29 and 30. These two projects (with negative weights in the objective function) did not appear in the solution.

(2) At each step, a group of projects entered the solution. Within such a group, ranking is impossible. However, the groups can be made smaller, even to include single projects, by carrying out the solution in more steps. This was not done in the present study because of the computer-time constraint.

(3) In each step, some projects appeared at less than full capacity. These are the last projects to be selected in that step, and the first to be entered in the following step. The remaining projects appeared at full capacity as expected.

(4) The order of entrance in the solution was taken as the order of priority. However, projects included in steps 5, 6, 7 are identical except for the output of project No. (1), which has been increasing till it reached capacity at the eighth step. This was taken to mean that after the projects included in step 5, project (1) is next in priority, therefore any increase in capital

and foreign exchange go into it. For this reason we assigned priority "6" to this project, while project No. (7), which also entered at step (8) took priority "7".

Table (2) below shows in the first column the priorities assigned to the different groups of projects using our suggested method. In column 2, 3, 4 and 5 , we list the priorities assigned by the alternative partial criteria discussed in Chapter (4). One should note that the ranking provided by the composite criterion (column 5) is very close to our ranking, especially when we note that ours is done for groups. The ranking shown in this table is based on the estimated coefficient reported in Table III of the Appendix.

Table (II)

Ranking of Projects By Alternative Criteria

Project No.	(1) Suggested Ranking	(2) V/K Criterion	(3) E/K Criterion	(4) B/K Criterion	(5) $\frac{V+E+B}{K}$ Criterion
1	6	29	30	9	24
2	8	28	23	13	22
3	1	26	20	2	5
4	1	25	26	3	6
5	8	30	29	12	26
6	8	18	24	23	25
7	3	9	18	8	10
8	8	7	3	5	8
9	4	20	14	11	13
10	8	14	4	25	28
11	8	22	16	24	27
12	2	3	6	14	3
13	4	13	5	18	17
14	4	5	15	20	9
15	1	8	19	17	16
16	3	4	2	16	4
17	7	12	8	22	21

Project No.	(1) Suggested Ranking	(2) V/K Criterion	(3) E/K Criterion	(4) B/K Criterion	(5) $\frac{V+E+B}{K}$ Criterion
18	2	2	1	27	2
19	2	9	17	6	7
20	4	27	12	9	19
21	1	24	10	7	11
22	1	23	9	4	12
23	5	19	7	19	20
24	5	15	11	15	15
25	8	21	28	10	18
26	8	17	27	21	23
27	1	6	13	1	1
28	4	1	25	28	14
29	-	11	21	26	29
30	-	6	22	29	30

One should stress again that our ranking should not be used as a policy guide unless the assumptions on which it is built are realized, and that no estimate of externalities are available.

The method is general enough to allow for the introduction of any number of constraints concerning the other factors of production. It allows also for interbranch, and intersectoral of priorities.

- - - - - - - - -

APPENDIX

Table I.

Data on Thirty Industrial Projects

In thousand L.E.
Fixed Prices

Project No.	Local Currency	Foreign Exchange	Production			Value Added	Value of Imported Materials	Exports		Employment	
			Unit	Qty	Value			Qty	Value	Number	Wages
1	34000	42000	Ton	800000	42318	18720	1548	405000	16587	2500	850
2	7375	16625	Ton	32000	14000	6572	1030	—	—	2000	800
3	303	760	Ton	80000	4640	239	38	25000	825	100	37
4	602	1338	Ton	75000	5675	530	380	25000	1500	190	60
5	652	481	Ton	25000	1990	190	78	2000	140	80	27
6	124	185	Ton	27000	1820	169	125	—	—	65	13
7	661	2297	Ton	22500	3118	1113	112	4000	520	260	90
8	248	877	Ton	1590	1386	505	17	295	259	340	119
9	221	684	Ton	200	450	292	124	100	200	120	42
10	44	303	Ton	600	180	68	87	—	—	60	21

Source. The Metallurgical Industrial

Table I. (Con'd.)

Project No.	Local Currency	Foreign Exchange	Production			Value Added	Value of Imported Materials	Exports		Employment	
			Unit	Qty.	Value			Qty	Value	Number	Wages
11	265	643	Ton	130000	867	273	292	—	—	100	40
12	76	299	Ton	6000	890	340	10	—	—	85	32
13	180	431	Ton	100	400	280	65	—	—	200	80
14	59	266	Ton	3450	424	181	30	—	—	30	9
15	45	50	Ton	500	1160	83	15	—	—	20	6
16	178	1197	Ton	600	1540	728	65	—	—	320	100
17	410	902	Ton	6000	1135	650	388	—	—	500	150
18	20	135	Ton	600	180	110	45	—	—	200	60
19	380	920	Ton	20000	1480	700	100	7000	420	200	56
20	271	640	Ton	2400	445	205	40	1000	160	250	82

Table I. (Con'd.)

Project No.	Local Currency	Foreign Exchange	Production			Value Added	Value of Imported Materials	Exports		Employment	
			Unit	Qty	Value			Qty	Value	Number	Wages
21	479	597	Ton	2000	220	480	66	2500	375	500	152
22	166	114	Ton	10000	600	153	83	5000	250	150	55
23	181	464	Ton	6000	540	240	75	—	—	230	70
24	297	906	Ton	10000	1100	450	50	—	—	300	90
25	5305	9810	Ton	40000	1184	6139	3408	20000	5240	730	400
26	1265	4455	Ton	16000	4330	1805	1000	—	—	300	100
27	395	2100	Ton	6800	3705	1024	100	6800	2305	300	84
28	150	750	Ton	5000	1800	980	723	—	—	40	15
29	207	500	Ton	1500	900	343	400	—	—	75	25
30	44	59	Ton	1500	320	66	214	—	—	15	5

Table II: Programme Output in The Nine Steps.

in thousand L.E.

Project No.	(1) K = 2.5 F = 5	(2) K = 5 F = 10	(3) K = 7.5 F = 15	(4) K = 10 F = 20	(5) K = 15 F = 30	(6) K = 20 F = 40	(7) K = 30 F = 60	(8) K = 45 F = 40	(9) K = 55 F = 102.7
1	10 ≡	53760 ≡	98422 ≡	133648 ≡	243197 ≡	360844 ≡	596138 ≡	800000	800000
2								257655 ≡	320000
3	80000	80000	80000	80000	80000	80000	80000	80000	80000
4	75000	75000	75000	75000	75000	75000	75000	75000	75000
5									25000
6									27000
7		8500 ≡	22500	22500	22500	22500	22500	22500	22500
8									1590
9				200	200	200	200	200	200
10									600
11									130000
12	876 ≡	6000	6000	6000	6000	6000	6000	6000	6000

Table II. (Con'd.)

Project No.	(1) K = 2.5 F = 5	(2) K = 5 F = 10	(3) K = 7.5 F = 15	(4) K = 10 F = 20	(5) K = 15 F = 30	(6) K = 20 F = 40	(7) K = 30 F = 60	(8) K = 45 F = 40	(9) K = 55 F = 102.7
13			6	100	100	100	100	100	100
14				3450	3450	3450	3450	3450	3450
15	500	500	500	500	500	500	500	500	500
16			6000	6000	6000	6000	6000	6000	6000
17								6000	6000
18		600	600	600	600	600	600	600	600
19		20000	20000	20000	20000	20000	20000	20000	20000
20				2400	2400	2400	2400	2400	2400
21	2000	2000	2000	2000	2000	2000	2000	2000	2000
22	10000	10000	10000	10000	10000	10000	10000	10000	10000
23					6000	6000	6000	6000	6000

Table II. (Con'd.)

Project No.	(1) K = 2.5 F = 5	(2) K = 5 F = 10	(3) K = 7.5 F = 15	(4) K = 10 F = 20	(5) K = 15 F = 30	(6) K = 20 F = 40	(7) K = 30 F = 60	(8) K = 45 F = 40	(9) K = 55 F = 102.7
24				4512 *	10000	10000	10000	10000	10000
25									40000
26									16000
27	6800	6800	6800	6800	6800	6800	6800	6800	6800
28				5000	5000	5000	5000	5000	5000
29									
30									

Note : The figures of each column represent the result of each step of the programme on the electronic computer. The figures with a star * , symbolize the fact that the output of the project is not in its full production capacity.

Table III.
Estimated Coefficients for Alternative Criteria

Project No.	(1) V/K	(2) E/K	(3) B/K	(4) $\frac{V + E + B}{K}$
1	0.55	0.025	+ 0.44	0.51
2	0.59	0.108	- 0.13	0.85
3	0.78	0.122	+ 2.59	3.500
4	0.88	0.099	+ 1.86	2.84
5	0.29	0.041	+ 0.095	0.42
6	1.36	0.104	- 1.007	0.45
7	1.68	0.136	+ 0.61	2.43
8.	2.04	0.479	+ 0.97	3.48
9	1.32	0.190	+ 0.34	1.85
10	1.54	0.477	- 1.77	0.04
11	1.06	0.151	- 1.102	0.08
12	4.47	0.421	- 0.15	4.76
13	1.55	0.444	- 0.36	1.63
14	3.07	0.153	- 0.51	2.71
15	1.86	0.133	- 0.33	1.64
16	4.09	0.561	- 0.31	4.28
17	1.58	0.366	- 0.95	1.00
18	5.5	3.000	- 2.25	6.25
19	1.84	0.147	+ 0.84	2.83
20	0.75	0.300	+ 0.44	1.50

Table III. (Con'd.)

Project No.	(1) V/K	(2) E/K	(3) B/K	(4) $\frac{V + E + B}{K}$
21	1.00	0.317	+ 0.64	1.90
22	0.92	0.331	+ 1.00	2.25
23	1.33	0.386	- 0.41	1.30
24	1.51	0.303	- 0.16	1.66
25	1.15	0.075	+ 0.35	1.57
26	1.42	0.080	- 0.79	0.71
27	2.59	0.212	+ 5.57	8.38
28	6.53	0.100	- 4.82	1.81
29	1.65	0.120	- 1.93	- 0.10
30	1.50	0.113	- 4.86	- 3.25

Note : The figures in column No. 1, 2 and 3 represent the results of the application of value added /capital criterion, employment (in terms of wages) /capital criterion for the thirty projects. Figures in column No. 4 represents the productivity of one Egyptian Pound of output on the objectives of development, $\frac{V + E + B}{K}$ where B represents the value of production exports mines the value of imported materials.

REFERENCES

1. Abdel-Rahman, H. Comprehensive Economic Planning in The U.A.R. Memo. No. 238, Sept. 1962, INP. Cairo , U.A.R.

2. Amer , R. Basic Principles In Linear Programming, Memo. No. 483, INP. 1964, Cairo, U.A.R.

3. Baumol, W.J. Economic Theory and Operation Analysis, Prentice-Hall, INC., Englewood Cliffs, New Jersey 1961.

4. Bryce , M.D. Industrial Development, McGrow Hill Book Company Inc., N.Y. 1960.

5. Chenery, H.B. "Comparative Advantage And Development Policy", The American Economic Review, Vol. LI, March, 1961.

6. ———————. "Development Policies and Programmes", Economic Bulletin For Latin America, III March 1958.

7. Dantzig, G.B. Linear Programming And Extention Princeton University Press, N.J. 1963.

8. Dorfman, Samuelson and Solow, Linear Programming and Economic Analysis, McGrow Hill Book Company, INC. N.Y. 1958.

9. El-Emam, M.M. Planning for Economic and Social Development, Arab League, The Institute of Higher Studies 1963.

10. El-Tige, A.S. Towards a System for Determining Industrial Priorities, Memo. No. 545, 1965, INP. Cairo, U.A.R.

11. Engert, E. The Role of Industrialization in Development, Meme. No. 384, INP. Cairo, U.A.R.

12. El-Kafrawy, M. Mathematics For Planners and Economists, Memo. No. 735, 1965, INP. Cairo, U.A.R.

13. E.C.A.F.E., Programming Techniques for Economic Development, Series No. 1, U.N. Bangkok, 1960.

14. E.C.A.F.E., Formulating Industrial Development Programming, Series No. 2, U.N. Bangkok, 1961.

15. Hansen, B. — The Theory of Economic Policy and Planning, Part II, 1964, INP. Cairo, U.A.R.

16. Hasan, S.F. — Introduction To Welfare Economics, Asia Publishing House, Bombay, 1963.

17. Linemann, H. — Lecture Notes on Economic Development Planning, Memo. No. 269, April 1963, INP. Cairo, U.A.R.

18. Qujme, A. — Theory And Policy of Accounting Prices, Contribution to Economic Analysis, Amestrdam 1960.

19. ————, — Lectures on Production Theory and Technique, INP. 1964, Cairo, U.A.R.

20. U. N. — Manual on Economic Development Projects, New York 1958, E/CN. 12/426/ Add. 1 /Rev. 1.

21. U. N. , — "Evaluation of Projects in Centrally Planned Economics", Industrialization and Productivity Bulleten 8, N.Y. 1964.

22. U. N. — Formulating and Economic Appraisal of Development, Vol. 1, 1951.

23. U. N. — Financial Evaluation of Capital Projects, Industrial Planning Course, 1965, INP., Cairo, U.A.R.

24. Scitovsky, T. — "Two Concepts of External Economics", The Economics of Underdevelopment A.N. Agarwala and S.P. Singh, Oxford University Press 1958.

25. Solomon, M.J. — Quantitative Technique for Development Planning, Course 259, 1962/1963, Graduate School of Public and International Affairs, University of Pitsburch. U.S.A.

26. Said, G. — The General Theory of Keynes, Al-Bian El-Arbi Printing Office, 1960 Cairo, U.U.A.

27. Tinbergen, J. — Economic Policy: Principles and Design, North-Holland Publishing Company, Amesterdam 1956.

28. _____, — The Appraisal of Investment Projects, The Semi-input/output Method, Memo. No. 159, INP. Cairo, U.A.R., 1962.
