SHORT TITLE

PROJECT EVALUATION TECHNIQUES FOR ECONOMIC DEVELOPMENT

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PROJECT EVALUATION TECHNIQUES FOR ECONOMIC DEVELOPMENT : A SURVEY

A Thesis

Submitted in partial fulfilment of the requirements for the Degree of Master of Arts in the Department of Economics and Political Science

by

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August 1968

THESIS ABSTRACT

A. Weiner, PROJECT EVALUATION TECHNIQUES FOR ECONOMIC DEVELOPMENT: A SURVEY: Master of Arts Thesis; Department of Economics and Political Science; McGill University. (August, 1968).

After introducing the problem in Chapter I, a framework for assessing project evaluation techniques in the context of economic development is suggested in Chapter II. This presents the problem as one of maximizing social welfare comprising a multiplicity of objectives; and indicates the conditions that make Government intervention desirable. In Chapter III, general ranking-criteria formulations are described, their limitations are identified, and criteria for temporal sequencing of projects are described. Then, the principal criteria which have been proposed specifically for the evaluation of development projects are described and assessed. Finally, the whole approach of evaluating projects on a partial-equilibrium basis is evaluated. Chapter IV provides a summary and offers some conclusions, and is followed by a Bibliography of the subject.

ACKNOWLEDGEMENTS

It is impossible to adequately express the extent to which Professor C.J. Kurien's patience, encouragement, and clear-thinking have contributed to this thesis. Professor Kurien acted as a supervisor of this thesis, but his assistance has by far exceeded the normal demands of that function.

Professors C.B. Haver, J.C. Weldon and E.F. Beach have also provided me with important clarifications of matters directly relevant to the contents of the thesis. In addition, I have greatly benefited from having attended the graduate seminar on Development Planning chaired by Professors M. Inagaki and B. Higgins during the fall semester 1967, at Sir George Williams University.

Professor Ingerman, and graduate students, M. Hussein, K.Brewer, and E. Carrington have read parts of earlier drafts of the thesis and have offered helpful comments.

Miss V.Fall has provided her excellent typing and editing services and Miss E. Blair drew the diagrams.

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CHAPTER I

INTRODUCTION

The emergence of many nations to political independence in the post-war period and the pronounced international disparities in standards of living that modern communications media have made so apparent, have placed the problems of economic development in the forefront of world concern. From the consequent proliferation of study in this area, it has become evident that solutions to the problems afflicting the nations of Asia, Africa and Latin America require basic transformations of the social, cultural and political institutions and values of the peoples in these regions, as well as concerted effort in the economic sphere. [1] Governments have determined that they must significantly participate if these enormous tasks are to receive the urgent treatment that they demand; and the tool for government decision-making that has currently been selected in most of the low-income countries is planning.[2]

Development Planning entails rational choices among alternative courses of action, directed to the most effective means for attainment of economic development. [3] Among the governments that employ Development Planning, marked variations of scope and methodology are evident. [4] Nevertheless, all these variants ultimately confront choices of concrete alternatives among which to allocate resources; [5] and if

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1. See e.g., B.F. Hoselitz, "Noneconomic Factors in Economic Development", American Economic Review; (May, 1957) pp. 28-41; and W.W. Rostow, The Stages of Economic Growth; Harvard University Press; Cambridge, Massachusetts; (1960), especially Chapter 3.
2. W.A. Lewis; Development Planning; Allen & Unwin; London. (1966); p.13.
3. c.f. United Nations; Planning for Economic Development; New York; (1963) p.6
4. c.f.,e.g. W.A. Lewis and United Nations, op.cits. pp. 13 and 4 respectively.
5. See, e.g., United Nations, Manual on Economic Development Projects; New York, (1958); pp. 3-6.

choices are to be rational, systematic quantitative analysis of alternate investment possibilities will be required.[1] This latter, is the task of project evaluation.

Thus project evaluation requires the formulation of criteria for comparisons of the advantages and disadvantages attendant upon alternate allocations of resources to the production of specific goods and services.[2] The scope of the decisions which these criteria are designed to guide include: the choice of goods and services to be produced; the choice of techniques to be employed in their production; and, the temporal sequence in which specific projects will be introduced. The purpose of this study will be to survey the considerations that accompany the evaluation of projects in low-income countries that have adopted economic development as a primary social priority, and to assess the project evaluation criteria that have been proposed for operational decision-making.

Accordingly, Chapter II will provide a theoretical framework in which the multiplicity of proposed project evaluation techniques may be assessed for their contribution to the problem of economic development, by describing an approach to Development Planning and outlining the considerations which justify Government intervention in the allocation of resources. Chapter III will survey operational project evaluation criteria. General criteria forms and their respective limitations will be described; they will then be compared to isolate their specific

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1. c.f. R.N. McKean; Efficiency in Government Through Systems Analysis; John Wiley; New York, (1958), Chapter 1.
2. United Nations; Manual on Economic Development Projects; op.cit., p.xiii.

biases and to determine the circumstances under which they provide compatible rankings of projects; and the approach to the problem of scheduling the initiation of projects will be examined. Secondly, criteria formulations which have been specifically proposed for the evaluation of economic development projects will be described and evaluated from the perspective of the framework provided in Chapter II. Finally, the question of the fundamental validity of the criterion-approach will be examined. Chapter IV will provide a summary of the study and will offer some conclusions.

CHAPTER II

A Framework for Project Evaluation

In the previous chapter, 'economic development' was referred to as the objective of Development Planning without, however, specification of the content of this term. As Professors Okun and Richardson have pointed out, the concept of economic development is difficult to define.

> "Despite the easy familiarity with which we speak of 'economic development', the concept turns out, upon examination, to have rather complex and elusive meaning and implications." [1]

Two basic senses in which the concept is employed may be differentiated. In the 'positive' sense, economic development is employed to describe the historical process by which currently industrially-advanced nations like the United States and Britain have arrived at their present states.[2] In the 'normative' sense, economic development describes a process of change over time in an economy which, on balance, is judged desirable. [3] It is in this latter sense, that the concept is employed in this study.

Various criteria for international and intertemporal comparisons of economic development have been devised, such as real per capita income and level-of-living indeces, but none of these has proven entirely satisfactory. [4] Essentially, the failure of these efforts at quantification is due to the fact that economic development consists in the attainment

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1. B.Okun and R.W. Richardson (eds.), Studies in Economic Development; Holt, Rinehart and Winston; New York, (1961); p.230
2. W.W. Rostow, op.cit., and A. Gerschenkron, Economic Backwardness in Historical Perspective;Harvard University Press; Cambridge, Mass. (1962); pp. 353-359
3. B.Okun and R.W. Richardson, op.cit., and J. Viner; International Trade and Economic Development;Clarendon Press; Oxford; (1953); Chapter VI.
4. For a survey of proposed indeces of economic development see J.W.Mellor; The Economics of Agricultural Development;Cornell; Ithica;(1966);Chapter 1.

of a multiplicity of objectives (economic, political, social and cultural) which to some degree are specific in time and place, being, to an important extent, influenced by the historical experience of the country. Moreover, the objectives are generally not fully complementary,[1] so that the attainment of higher levels of performance, may after some point, require sacrifices with respect to the levels of performance of other objectives; and measurements of development derived from any single objective will provide an inadequate index.

Thus to conclude these introductory remarks, the object of Development Planning may be described as the maximization of a social welfare function comprising the multiplicity of objectives prescribed in the Development Plan of the country, subject to the constraints imposed by technology and the resource endowment. Therefore, in the context of economic development, project evaluation may be described as that aspect of Development Planning concerned with the formulation of decision-criteria that will be operative at the project or microeconomic level, and will be consistent with social welfare maximization.

The present chapter will attempt to provide an appropriate framework in which the problem of project evaluation may be surveyed. First, a general treatment of social welfare maximization in the context of Development Planning, will be presented. The remainder of the chapter will examine three aspects of welfare maximization in the same context:

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1. "Incomplete complementarity" is used in this study to refer to objectives which may exhibit some complementarity over initial portions of social transformation functions, but after some point become competitive. (See following for diagrammatic representations.) Thus for example, national income and the income of a poor region may be complementary over the range where both are at low levels. However, after a point, further increases in income to the region might require a decrease of national income, if say, comparative advantage is violated.
S.A. Marglin; Public Investment Criteria; Allen and Unwin; London; (1967); p.27.

the violation of conditions of perfect competition; the exceptions to Pareto optimality, given perfect competition; and, the circumstances under which the achievement of Pareto optimality is inconsistent with the objectives of economic development.

A. The Planning Problem

The task of development planning is to provide the mechanism through which public policy may be pursued in a rational manner. [1] If we hypothesize a "perfectly democratic" government, its primary policy objective will be the maximization of social welfare. Moreover, the government cannot be satisfied with a static maximization, but must take a broad time perspective, so that welfare maximization must represent the maximization of utility over time.

Thus conceptually, there can be an instantaneous utility function,

$$U = U(y_1, y_2, \ldots\ldots, y_n)$$

where $y_1, y_2, \ldots\ldots, y_n$ are variables representing levels of performance with respect to the 'n' objectives of policy, at a given point in time. Then maximization of social welfare may be represented as the maximization of W, where

$$W = W\left(\int_0^\infty y_1(t) \cdot e^{-i_1 t} dt, \ldots, \int_0^\infty y_n(t) \cdot e^{-i_n t} dt\right)$$

where $i_1, i_2, \ldots\ldots, i_n$ are time discounting rates for the 'n' objectives, respectively.[2]

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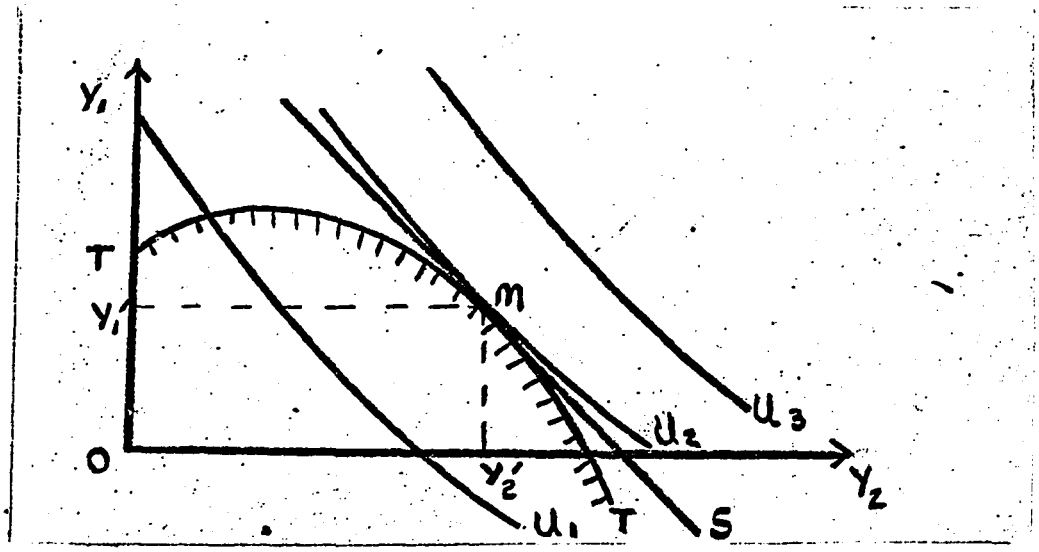
1. J.P. Rosenstein-Rodan, "Programming in Theory and Italian Practice"; Massachusetts Institute of Technology; Centre for International Studies; Investment Criteria and Economic Growth; Asia Publishing House, Bombay; (1955); pp.19-22.

2. The discount rate for any particular objective need not be a constant, but may itself be a function of time. However, due to the complexities of identifying such a function, it is customary to assume it to be constant. See, for example, A.C. Harberger, "Techniques of Project Appraisal", in M.F. Millikan (ed.), National Economic Planning; National Bureau Economic Research; New York; (1967); pp.131-149; and P.Masse, Optimal Investment Decisions; Prentice-Hall; New Jersey, (1962); p.15.

There are constraints on the maximization of the social welfare function at any point in time, and over any finite interval of time due to limited resource availability and the state of technology, which can be represented by a 'social production frontier' or 'social transformation function'. The social transformation function will represent the maximum level of attainment of any particular objective, given the technology, resource endowments, and specified levels of attainment of all other objectives, produced at minimum social opportunity cost.[1]

Two dimensional geometry will be used to illustrate the explanation of the welfare maximization problem.

Figure 1.



1. For a discussion of the social transformation function, see J.de V. Graaff; Theoretical Welfare Economics;Cambridge University Press; London (1957); pp.19-22. The analysis proceeds on the assumption of "strict convexity" of the social transformation function; otherwise solutions may be neither unique nor optimal. See S.A. Marglin, op.cit., pp.35-37, for discussion and demonstration of the consequences of the violation of this assumption. With respect to the utility function, we assume that utility isoquants are concave from above. A similar geometric presentation (adapted for linear programming purposes) is presented in T.V. Vietroisz; "Locational Choices in Planning"; National Economic Planning; Max Millikan (ed.);National Bureau Economic Research; New York (1967) pp. 104-111.

In the accompanying figure, TT represents the social transformation function between various achievement levels of two objectives of public policy, y_1 and y_2. U_1, U_2, U_3 are three social utility isoquants of an entire isoquant map representing respectively, ordinally higher levels of utility, at a particular point in time. Either by inspection or by use of the mathematics of constrained maximization,[1] it can be determined that utility maximization occurs at the tangency point 'm' with the attainment of the two objects at the levels 'y_1'' and 'y_2'', respectively. The interpretation of this result is that maximization requires the equality of the (negative value of) marginal rate of transformation between the two objectives with the (negative value of the) ratios of the marginal weights (represented by the slope of the line 'S'.) Alternately, the slope of the transformation function can be interpreted as the marginal trade-off or as the ratio of the marginal opportunity costs of 'y_1' and 'y_2'. The criterion for utility maximization thus established is: equality of the ratio of the marginal

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1. To maximize $U = U(y_1, y_2)$, subject to $T(y_1, y_2) = 0$

   Maximize the Legrangian expression $L = U - \lambda T$, where λ is the Legrange multiplier.

   Thus $\dfrac{\partial L}{\partial y_1} = U_1' - \lambda T_1' = 0,$

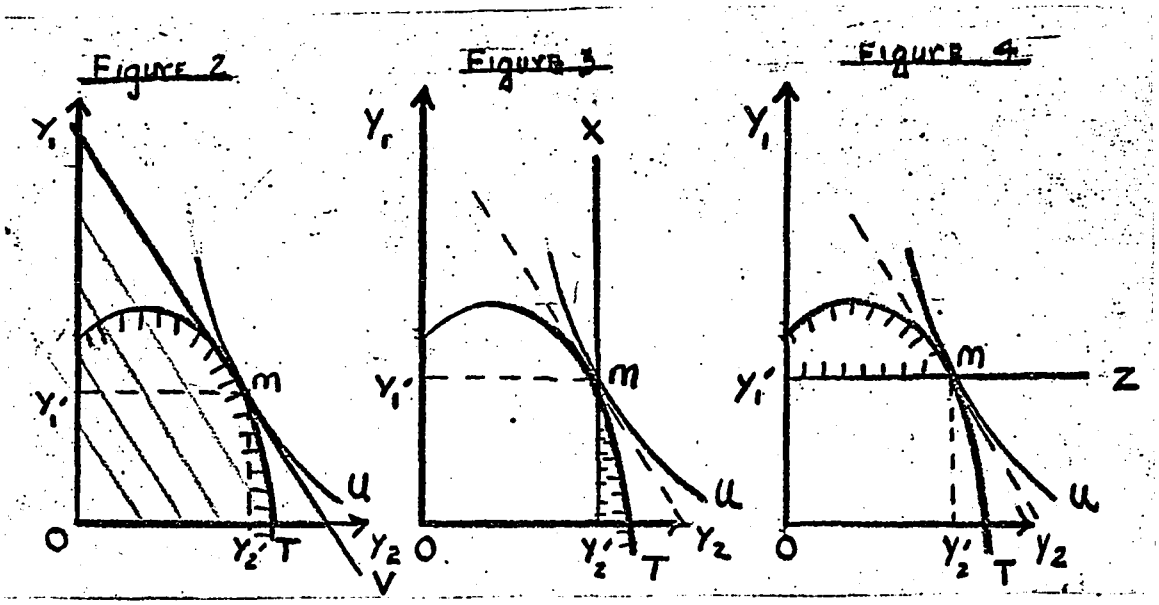
   and $\dfrac{\partial L}{\partial y_2} = U_2' - \lambda T_2' = 0,$ are necessary conditions for maximum.

   $U_1'/U_2' = T_1'/T_2'$. (The fulfillment of the second-order conditions is assured by the shapes of the two functions as represented in the figure.) See previous footnote P.7, No.1.

   Or, $\dfrac{U_1'}{T_1'} = \dfrac{U_2'}{T_2'}$ eg. $\dfrac{MU_1}{MC_1} = \dfrac{MU_2}{MC_2}$

weights of the two objectives with the ratio of their marginal opportunity social costs.

The above criterion suggests a planning methodology under real circumstances when, "... policymakers cannot know the shape of the transformation function in its entirety, nor can they be expected to articulate their preferences...," among alternative contributions of 'y_1' and 'y_2' in the form of a complete set of U-curves.[1] Three items of information resulted from the maximization procedure of Figure 1: the relative weights to attach to the two objectives (the slope of line S): the level of performance with respect to objective y_1 (y_1'); and, the level of performance with respect to objective y_2 (y_2'). The intention of the presentation of Figures 2, 3 and 4 is to illustrate that prior information of any one of the above three items and full knowledge of the transformation function would have been sufficient to arrive at the utility-maximization solution. Thus, given the critical, "strict convexity" assumption for



1. See S.A. Marglin, Public Investment Criteria; op. cit., p.30. Much of the presentation in this section follows a similar pattern to that of Marglin's excellent work.

the social tranformation function,[1] three alternative (and equivalent) approaches to the problem of utility maximization (in two dimensional space) are suggested.

1. Assign weights to the objectives of an objective function and maximize:

$$\text{Max: } y_1 + w \cdot y_2 \quad ,$$

where 'w' provides the relative weighting of the two objectives, and is equal to the (negative value of the) slope of line 'V' in Figure 2.

2. Maximize with respect to the first objective, subject to a specified constraint on the second:

$$\begin{aligned} \text{Max: } & y_1 \\ \text{Subject to: } & y_2 \geq y_2' \end{aligned} \quad .$$

3. Maximize with respect to the second objective, subject to a specified constraint on the first:

$$\begin{aligned} \text{Max: } & y_2 \\ \text{Subject to: } & y_1 \geq y_1' \end{aligned} \quad .$$

If policymakers desire quantitative results from the planners, they will have to assign weights to the objectives comprising their utility function.[2] However, they have the choice of doing so explicitly or, implicitly by specifying constraint levels on some of the objectives.[3] Unfortunately, the probability of the policymaker arbitrarily assigning the "correct" weight to maximize utility, is zero. Thus, prior specification of the relative weights of the objectives of the social utility

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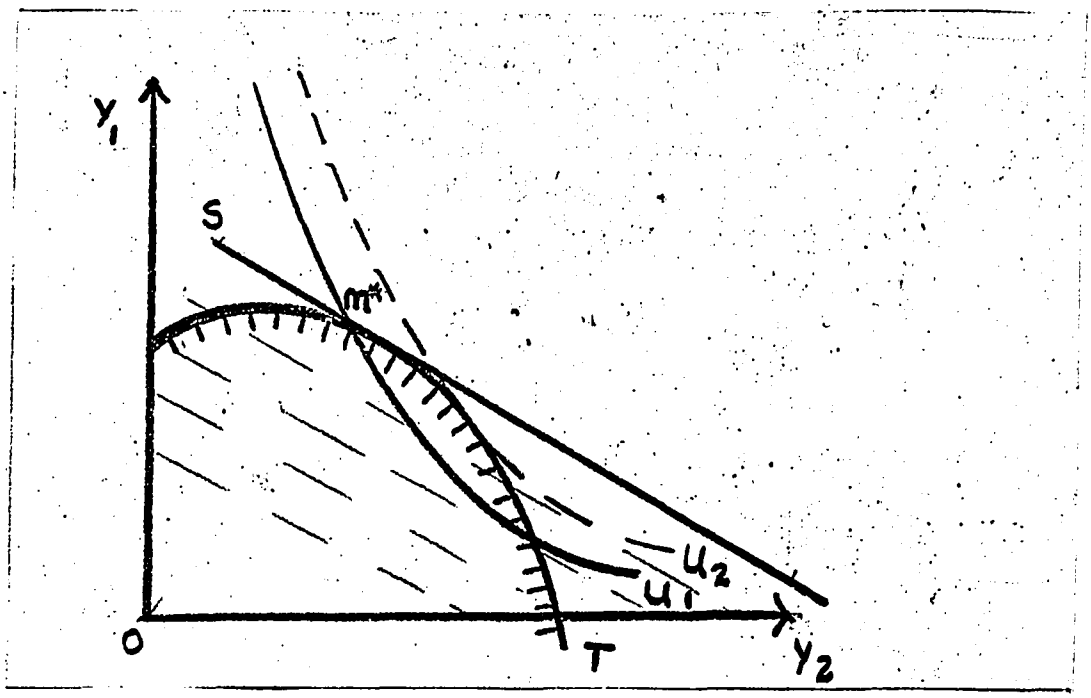
1. See previous footnote, Page 7.
2. United Nations (ECAFE), Programming Techniques for Economic Development; Bangkok, (1960); pp. 35-40
3. S.A. Marglin, op.cit., p.29; also T. Vietorisz, "Locational Choices in Planning", op.cit., Appendix I.

Fig. 5



function, and their combination into an objective function to be maximized, (subject to the constraint of the social transformation function) will tend to result in a non-optimal position such as 'm*'in Figure 5.[1]

However, a procedure suggests itself for the real world conditions of incomplete knowledge of the social transformation function and incomplete specification of social utility functions. At 'm*'(Fig.5), the marginal opportunity cost between the two objectives is equal to their pre-assigned weights, represented by the slope of 'S'; but at the levels of performance of the two objectives at 'm*', the ratio of their marginal utilities as represented by the social utility isoquant 'U_1', indicates a greater willingness to sacrifice additional units of y_1 for

1. Similarly, non-optimal results can be expected by the two equivalent alternative approaches described: maximizing with respect to one of the objectives subject to a specified constraint upon the other.

more of y_2 than is represented by the opportunity cost conditions at that point. In the next round of the planning process, the government can be expected to assign a relatively higher weight to the objective y_2. The planning process may thus be viewed as an iterative process with weights (and/or constraint levels) set on the objectives of a social utility function, which are employed in the design of the decision-criteria of the investment program (composed of individual projects). In the light of the new information thus generated, new weights can be assigned and a new programme generated which can again be tested for compatibility with the social utility function, until the optimal program (or a satisfactorily close approximation to it)[1] is attained.

Thus far, the presentation has been limited to an examination of the logic of the maximization procedure with respect to an instantaneous social utility function, whereas the problem of planning was formulated as the maximization of a social welfare function representing utility maximization over time. Problems associated with the choice of appropriate social discount rates are central to the planning problem, and to project evaluation techniques, but reasons of organization recommend the deferment of detailed discussion of this question to another section of the study. For the present, suffice it to record that the problem of choosing between greater utility now or even more in the future is, in principle, perfectly similar to the problem of choosing the 'bundle' of objectives that maximize instantaneous utility; if the axes and the social transformation function are appropriately redefined to indicate

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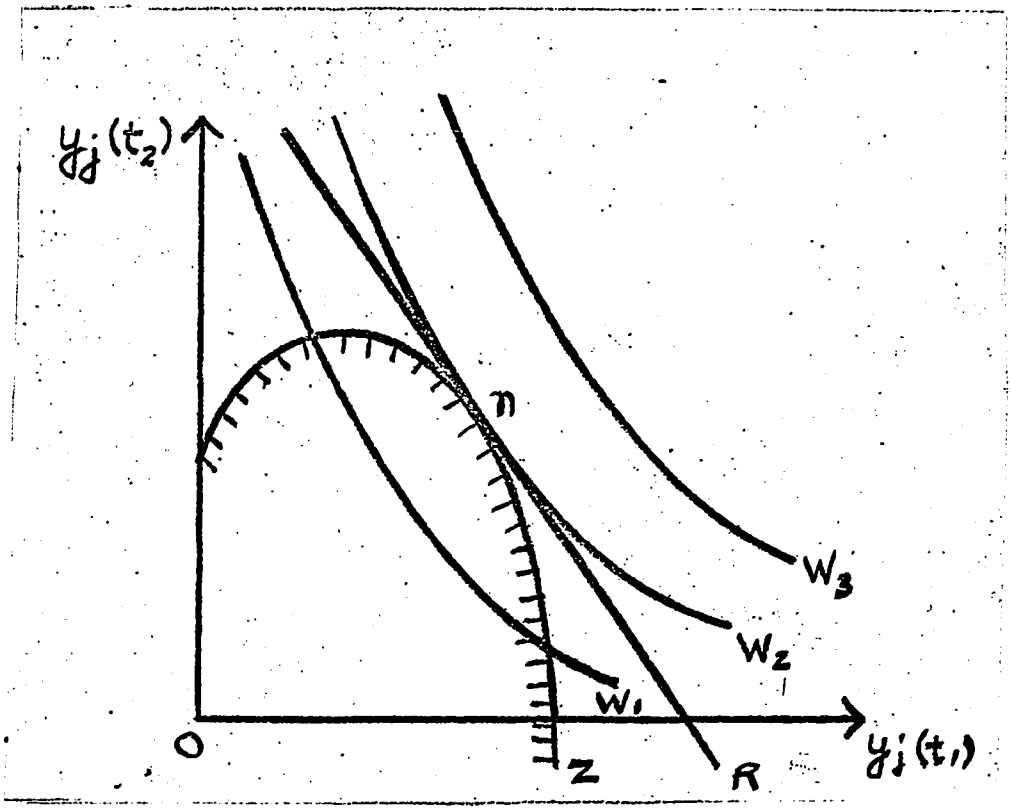
1. Iteration should cease when the expected gain from an additional iteration fails to cover the planning costs that it entails. See S.A. Marglin, Approaches to Dynamic Investment Planning; Amsterdam; (1963); p.78.

Fig. 6



performance levels at two time periods (1 and 2) for a given objective (y_j), and the social welfare function (the W-function) is maximized. The slope of the line 'R' may be interpreted as representing both the marginal 'social productivity' of investment and the marginal social rate of time preference at the point 'n', of social welfare maximization.

To summarize, any given project is likely to have some effects upon all the objectives of the social welfare function. The choice of project evaluation criteria is thus intimately related to the objectives of the Development Plan. 'Benefits' must refer to the contributions of the project to these objectives, and 'costs' must reflect opportunity

costs in terms of these same objectives.[1]

> "Benefits and costs, it should be emphasised, have only instrumental significance; we can speak properly of net benefits only as applying to given objectives, such as 'efficiency net benefits' or 'redistributive net benefits'. A criterion of maximizing net benefits in the abstract is meaningless." [2]

Project evaluation criteria must be designed so that the 'correctly' weighted, net benefits (i.e., benefits accrued less the benefits foregone from potential alternate employments of resources) from the entire investment programme will be maximized.

B. The Scope for Government Intervention

A fundamental theorem of welfare economics which derives from general equilibrium theory states that under perfect competition, given perfect divisibility, the market mechanism will solve the problem of the 'efficient' allocation of resources[3]; where efficiency can be defined as a 'Pareto optimal' position at which it is impossible to increase the welfare of any individual without causing a reduction of the welfare of at least one other individual in the system.[4] Conventionally, the exceptions to the rule of efficient market allocation under perfect competition, when social costs and benefits differ from their private counterparts, are classified under the two headings - nonmarket inter-

dependences

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1. Compare for example R.N. McKean, Efficiency in Government Through Systems Analysis;op.cit., p.50; and J. Tinbergen; The Design of Development; The Economic Development Institute, IBRD; John Hopkins Press; Baltimore (1958); p.33.
2. A. Maas and others; Design of Water Resource Systems; Harvard University Press; Cambridge (1962); p.19.
3. W.J. Baumol, Economic Theory and Operations Analysis; Prentice-Hall; Englewood Cliffs; New Jersey (1961) pp. 253-256.
4. V. Pareto, Manuel d'Economie Politique; Paris (1909)

dependence and public goods.[1] On economic grounds, justification for government intervention in the market mechanism of a mixed-enterprise economy may be derived from this theorem when the private market economy violates the conditions of perfect competition, and in cases of the above mentioned exceptions. In addition, in the context of the present study, a third class of justification may be postulated viz., when the objectives of public development policy which comprise the social welfare function are not consistent with the attainment of Pareto optimality.

Thus, with the static,[2] general equilibrium framework providing a point of departure, the following proceeds to examine justifications for the utilization of investment criteria that diverge from the market test of private profitability, under the headings of the three categories described above.

B.1.(a) Imperfections in the Competitive Structure

One source of departure from the requirements of perfect competition arises when elements of monopoly or monopsony exist in the economy due to market organization that prevents free entry into some fields of production. The profit-maximizing monopolist sets his prices at a level which corresponds to the equality of marginal cost with marginal revenue, and thus causes a violation of the requirements of efficient resource

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1. M. Blaug, Economic Theory in Retrospect; Irwin; Homewood,Illinois; (1962); p.548. There is not full agreement on the appropriateness of this classification. For example, Professor J.C. Weldon argues that public goods represent a special case of externality, and that, therefore, all exceptions can be adequately classified under the single heading of 'externalities'. CJEPS, Vol. 32, No.2, (1966); pp. 230-238: "Public Goods (and Federalism)". A similar position is also taken by Professor T. Scitovsky, "Two Concepts of External Economies"; Journal of Political Economy; (April, 1954);Vol.62; pp. 143-151. Reprinted in Agarwala and Singh, The Economics of Underdevelopment;Oxford University Press; New York; (1963); p.297-fin.
2. Tastes, technology and ownership distribution are given.

allocation, leading to distortions throughout the economy.[1] When monopoly elements exist which are interdependent with projects under appraisal, appropriate corrections of prices should be made to correct this divergence between private marginal costs and social marginal costs.[2]

A second departure from perfect competition arises when the government intervenes in the market mechanism by charging taxes and tariffs or by granting inducements or subsidies to specified areas of the economy. These government interventions will have differential impacts in various markets and will thus distort the structure of prices. Furthermore, taxes, tariffs and subsidies are merely internal transfer payments and, therefore, do not represent real costs to the economy. Evaluations of the effects of projects should, therefore, include adjustments for these effects.[3]

Unemployment and under-employment are very prevalent phenomena in low-income countries.[4] In these cases, wages will exceed social opportunity costs, and a corresponding adjustment will consequently be required.[5]

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1. M.S. Friedman, Price Theory; Aldine; Chicago (1962); pp. 61-67. Note, however, that if the degree of monopoly is uniform throughout the economy, the problem is obviated. See, for example, W.J. Baumol, Economic Theory and Operations Analysis; op.cit., p.257.

2. See, for example, H.B. Chenery, "The Application of Investment Criteria", Quarterly Journal of Economics; Vol.67; (February 1953); pp.76-96. See also O. Eckstein, "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics"; Quarterly Journal of Economics; Vol.71; (1957); pp. 56-85.

3. See Eckstein; Chenery; ibid., and United Nations, Manual on Economic Development Projects, op.cit., p.207

4. There is a very extensive literature in this area; a few examples are W.A. Lewis, "Economic Development with Unlimited Supplies of Labour"; The Manchester School; (May 1954); pp. 139-191: H. Leibenstein, "The Theory of Unemployment in Backwood Economies"; Journal of Political Economy; (April 1957): R. Nurkse, Problems of Capital Formation in Underdeveloped Countries; Oxford; (1953).

5. An example of the type of calculation required to measure the social opportunity cost of unemployed labour, see infra, p.53.

It should be noted, however, that the existence of unemployed labour is, per se, not necessarily proof of market imperfection; the existence of a minimum wage level at some 'institutional' or 'subsistence' wage rate may be consistent with perfect competition.[1] However, imperfections in the labour market in low-income countries can generally be attributed to institutional or cultural impediments to labour mobility which are commonly found[2], and imperfections in information transmission because of underdeveloped infrastructures.[3]

The final source of market imperfection to be considered, arises from the fixed exchange rate structure under which the international monetary system is currently organized. As a result, foreign exchange rates are frequently out of equilibrium so that import prices do not accurately represent their social opportunity costs. Again,corrections must be applied to offset such distortions.[4]

B.1.(b) Indivisibilities in Production

Production indivisibilities do not fit easily into the broad categories of classification assumed in this study, because their existence, while not necessarily presenting an exception to perfect competition, do prevent the attainment of conditions of perfect competition.

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1. I thank Professor J.C. Kurien for this clarification.

2. See, for example, W.E. Moore, "Labour Attitudes Towards Industrialization in Underdeveloped Countries"; American Economic Review; (May 1955); pp. 156-165: B.F. Hoselitz, "Noneconomic Factors in Economic Development"; op.cit., pp.28-41 and C. Wolf,Jr., "Institutions and Economic Development"; American Economic Review; (December 1955); pp. 867-883.

3. For example, see international comparisons of indeces of literacy in S. Kuznets, Economic Change; New York; (1953); p.220.

4. See, for example, M. Bruno, "Some Applications of Input-Output Techniques to the Analysis of the Structures and Development of Israel's Economy"; in T. Barna (ed.) Structural Interdependence and Economic Development; MacMillan; New York; (1963); see also H.B. Chenery, "The Application of Investment Criteria", op.cit.

The principal problem lies in the fact that significant production indivisibilities result in a wide range of decreasing costs and thus to the creation of 'natural monopolies'. [1]

The first treatment of production indivisibilities by Dupuit[2] in 1844 also marks the origin of cost-benefit analysis. Dupuit's analysis was concerned with the establishment of criteria for determining the social desirability of investments like roads, bridges, canals and railways; the analysis of these problems remains basically unaltered. If there are decreasing average costs over the range of output relevant to its demand conditions, the firm cannot avoid incurring a loss, if conditions of efficient resource allocation are to be maintained throughout the economy with price equal to marginal cost. Dupuit's test of whether such an operation should receive public subsidy consisted in whether revenues plus consumers' surplus (as measured by the area under the demand curve) [3] exceeded the projects costs.[4]

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1. See A.P. Lerner, Economics of Control; MacMillan; New York; (1946) p. 188.
2. J. Dupuit, "On the Measurement of the Utility of Public Works," first published in Annales des Ponts et Chaussees; Ser. 2; No. 8 (1844); English translation in International Economic Papers; No. 2; London; MacMillan; (1952) pp. 83-110.
3. For a comparison and appraisal of various concepts of consumers' surplus see I.M.D. Little, A Critique of Welfare Economics; (2nd.ed.) Oxford University Press; London; (1957); Chapter 10.
4. Compare with Lerner, op.cit.,Chapter 16. Lerner's solution is slightly different in that it includes consideration of any producer's surplus that might accrue. See, S. Enke, Economics for Development;Prentice Hall; Englewood Cliffs; New Jersey; (1963); pp. 274-276, for a discussion of considerations that enter into pricing policies for natural monopolies, with special reference to low-income countries.

B.1.(c) Incompatibility of Perfect Competition with Pareto Optimality

As previously stated, the market mechanism, organized under perfect competition will not result in the achievement of Pareto optimality when divergence occurs between social and private costs and benefits. With full cognizance of the disputed value of such a classification,[2] these divergences will here be described under the headings of non-market interdependence and public goods.

B.2.(a) Non-Market Interdependence

Non-market interdependence refers to interdependence between consuming and/or producing units which is direct, i.e. it does not act through the market mechanism.[1] Therefore, (by definition) in such cases, transactions that occur in the market will not reflect their full effect on society, so that perfect competition will not be sufficient to move the market economy to a position of Pareto optimality.

Direct interdependence occurs when a consumers' satisfaction are affected by the satisfactions of other consumers or by the activities of producers, that do not operate through the market mechanism; and when a producer's output is influenced by non-market activities of consumers or of other producers.[3] The case of direct interdependence between producers is generally known as "external economies and diseconomies" in equilibrium theory,[4] or as "technological external economies",[5] because

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1. T. Scitovsky, "Two Concepts of External Economies", op.cit., p.296.
2. See infra, p.15, f.n.3.
3. For examples of each of these cases and a discussion of their actual importance, see T. Scitovsky, op.cit., pp.296-298
4. ibid., p. 297. A discussion of external economies in the context of development economics follows.
5. J. Viner, "Cost Curves and Supply Curves"; Zeitschrift fur Nationalokonomie; Vol. 3 (1931); pp. 23-46.

their effects occur through the firm's production function.

While direct interdependence among consumers is recognised as a very pervasive phenomenon which weakens the applicability of an important segment of welfare economics,[1] technological external economies (as well as the two intermediate cases) occur infrequently and, therefore, do not significantly affect the analysis in the field of production.[2]

B.2.(b) Public Goods

Public goods or collective goods may be described as goods and services which have the property that they must be consumed in equal amounts by all.[3] Examples of collective goods are defence expenditure, internal security, public health and flood control. The difficulty associated with the pricing of public goods excludes the possibility of their coming into existence if left to private initiative. Whereas in the case of "normal" or "private" goods aggregate demand is derived by the horizontal summation of individual demand curves; in the case of public goods, individual demand curves must be summed vertically to

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1. See, for example, M.C. Kemp, "Welfare Economics: A Stocktaking"; Economic Record; Vol. 30 (1954); pp. 245-251, and T. Scitovsky, op.cit., p. 297; E.J. Mishan, "A Survey of Welfare Economics: 1939-59"; Economic Journal; (1959); Reprinted in American Economic Association and Royal Economic Society Surveys of Economic Theory;Vol.1; pp.154-222 suggests that direct interdependence between consumers is not likely to be a powerful force. Contrast with this the literature in development economics on the "demonstration effect".

2. See, for example, J.E. Meade, "External Economies and Diseconomies in a Competitive Situation"; Economic Journal; Vol. 62 (1952); pp. 54-67, and T. Scitovsky, op.cit., p. 299.

3. R.A. Musgrave, The Theory of Public Finance; McGraw Hill; (1959); New York; pp. 8-12; P.A. Samuelson, "The Pure Theory of Public Expenditure"; Review of Economics and Statistics; (November 1954); pp. 387-389; R.E. Stat; (November 1954; pp. 387-9 and November 1955; pp. 350-6, respectively. For a divergent view, see J.C. Weldon, "Public Goods (and Federalism)"; The Canadian Journal of Economics and Political Science; Vol. 2 (1966); pp. 230-238.

arrive at aggregate demand, because of their quality of being consumed by all members of society in equal quantities.

As Wicksell [1] has pointed out, attempts to discover individual demand functions are likely to be unsuccessful since individuals are likely to understate their demand (if they expect to have to pay on the basis of this criterion) when they are aware that the magnitude of their personal payments for consumption of the collective goods, will not alter the quantity which they will finally consume. Thus the market mechanism cannot solve the problem of resource allocation to collective goods, which must derive from some type of collective or government estimate; and the market will, therefore, fail to provide this type of attainable social benefit, so that a position of Pareto optimality will not be achieved.

B.3.(a) "Dynamic" External Economies

The literature concerned with the evaluation of projects, which has been evolved with special reference to the economic and structural context of public investment in the United States, stresses that only 'technological' external economies and diseconomies may appropriately be accounted among the effects of a project; [2] 'pecuniary' external economies, [3] which are reflected through the market mechanism by changes of related input and output prices, are declared irrelevant to assessments of social costs and benefits. Prest and Turvey state this argument as follows:

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1. K. Wicksell, Finanztheoretische Untersuchungen; Stockholm; (1896).
2. See, for example, McKean, op.cit., Chapter 8; A.R. Prest and R. Turvey, "Cost Benefit Analysis: A Survey"; The American Economic Association and the Royal Economic Society Surveys of Economic Theory; Vol.3; New York; (1966); pp. 155-207; J.V. Krutilla, "Welfare Aspects of Benefit Cost Analysis"; Journal of Political Economy; Vol. 61; No.3; (1961) pp. 226-235, reprinted in S.C. Smith and E.N. Castle (ed.) Economics and Public Policy in Water Resource Development; Iowa State University Press; Iowa; pp. 22-34.
3. See J. Viner, op.cit.

> "In other words, we have to eliminate the purely transfer or distributional items from a cost-benefit evaluation. We are concerned with the value of the increment of output arising from a given investment and not with the increment of value of existing assets." [1]

In a frictionless economy, any one of a set of competing projects representing equal quantities of expenditure would be expected to provide equal Keynesian multiplier effects.[2] Thus in each case these benefits would be offset by an equal opportunity cost of the project, so that this aspect of their contribution to welfare (in the Pareto sense) would have no relevance for a ranking criterion.

As has already been documented, technological external economies typically have a minor practical significance.[3] Thus it would appear that external economies would in general evolve little attention in discussions of project selection criteria. However, the literature of Development Economics provides a very prominent place to external economies, as, for example, in the following quotation by Professor Rodenstein-Rodan:

> "External economies may there [in economically depressed area] be of the same order of magnitude as profits which

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1. See Prest and Turvey, op.cit., p.160. Compare this formulation with the following conclusion by Graaff, op.cit., (p.92) "....the size-distribution dichotomy [in the valuation of an increment of output] is inconsistent with the basic Paretian value judgements that individual preferences are to count and that a cet.par.increase in one man's well-being increases social well-being." Nevertheless, with proper qualifications, their statement could be acceptable. To quote Krutilla, op.cit., p.24, "Kaldor's production-distribution dichotomy and the resulting test of an increase in real income appear supportable for the more or less marginal adjustments for which benefit cost criteria were originally developed and typically applied in the United States."
2. Given an aggregate marginal propensity to consume that is independent of income distribution.
3. See previous footnote, P.20, No.2.

appear on the profit and loss account of the enterprise." [1]

Professor Scitovsky has resolved this apparent contradiction by providing a definition of external economies which applies to the "theory of industrialization of underdeveloped countries",[2] in contradistinction to Meade's definition of technological external economies whose relevance applies to general equilibrium theory.[3] The former external economies may be said to occur "whenever the profits of one producer are affected by the actions of other producers." [4] Symbolically, this may be expressed as:

$$P_1 = P_1 (x_1, 1_1, c_1, \ldots; x_2, 1_2, c_2, \ldots) \quad ;$$

where,

P_1 represents the profits of the firm under consideration;

x_1 represents its output;

1_1, c_1, ... represent its utilization of factors of production;

and,

x_2, 1_2, c_2, ... represent the outputs, and the inputs, respectively of all other firms. Whenever non-zero terms at the right of the semi-colon are identified as operative, external economies may be said to occur.[5]

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1. "Problems of Industrialization of Eastern and South-Eastern Europe", Agarwala & Singh, p.250.
2. Scitovsky, "Two Concepts of External Economies", op.cit.
3. Meade, op.cit.
4. Scitovsky, op.cit., p. 300.
5. External diseconomies have the same definition, but their effects on P_1 are to reduce it.

Examples of "dynamic" external economies may be listed as follows:[1]

expansion in industry A may give rise to profits to

I an industry that is supplied by industry A with inputs;

II an industry that produces an input used in industry A;

III an industry whose product in complementary in use to the product of industry A;

IV an industry whose product is a substitute for a product used as an input in industry A; and

V an industry whose product is consumed by persons whose incomes are raised by the expansion of industry A.

The reasons why general equilibrium theory and development theory come to such different conclusions with respect to external economies, may first be found in the fact that countries that fall within the scope of the latter discipline tend to have an industrial sector which is small relative to optimum-sized production units which have been designed in the industrial countries.

> "The situation is very different in underdeveloped economies. There, a single investment can make a big addition both to the total marketable output of a product and to total money income, and this means that considerations of interdependence ... assume great importance. For, in such cases, estimates of the profitability and desirability of investment and of the optimum size of investment become very different when interdependence is taken into account from what they are when interdependence is ignored. It is obvious that the estimates which ignore interdependence are the wrong ones; and it can be and has been shown that the private entrepreneur makes estimates close to these when he bases his judgement on market information alone." [2]

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1. Compare Scitovsky, op.cit., p. 305.

2. T. Scitovsky, "Growth - Balanced or Unbalanced?"; in M. Abramovitz and others, The Allocation of Economic Resources; Stanford University Press; Stanford; (1959); 207-217; pp. 211-212

A second inadequacy of general equilibrium theory with respect to economic development, derives from the static nature of its assumptions. Adjustments to new investments do not occur instantaneously and simultaneously, but take place over time. Market prices, which provide the information with which investment decisions are made, reflect present conditions which objectives of the Development Plan may seek to radically transform, but not those of the future when operating costs must continue to be applied and the revenues from the project are earned. Where there are underdeveloped capital markets, stock exchanges, and futures markets in commodities,[1] market prices will tend to serve even less adequately as signalling devices for private investment.[2] Thus pecuniary external economies which may stimulate expansion in other sectors of the economy, but will not be reflected in market prices and hence, neither in calculations of private profit, should be considered as a social benefit deriving from the investment.

A third reason follows from the extent to which resources (especially labour) may be unemployed or underemployed, a factor which has received a very extensive treatment in the literature of Economic Development.[3] This argument gains particular strength when institutional

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1. See, for example, C.Wolf,Jr., "Institutions and Economic Development"; op.cit., pp. 867-883.
2. Professor K. Arrow has argued that futures markets could provide an adequate signalling device for investment decisions. See T.Scitovsky, "Two Concepts of External Economies"; op.cit., p. 306 (f.n.); also O.Eckstein, op.cit., p.58. However, L. Johansen has argued to the contrary. "Some Problems of Pricing and Optimal Choice of Factor Proportions in a Dynamic Setting"; Economica; Vol.34; (May 1967); pp. 131-152.
3. See Lewis, Nurkse etc. in previous footnotes.

imperfections[1] and structural imbalances[2] result in widely differing secondary stimuli from alternate investments. In cases where industrialization is desired but structural interdependence is at a low level in the economy, pecuniary external economies will be very important for economic development. For example, an export sector may be substantially expanded without inducing significant complementary investments in other sectors of the economy.[3] On the other hand, expansion of a sector which supplies domestic demand but requires substantial imported inputs and replacements, need not result in expansion of the exporting sectors, so that balance-of-payments disequilibrium may result, and dependence on aid may increase.[4]

Finally, Professor Scitovsky provides an important instance of external economies operating on the international level, in which case they may lead to private investment decisions with a bias against import substitution, in countries which are at low levels of industrialization.

> "....private profit....probably comes closer to registering the social welfare of the world as a whole than that of a single nation. Hence investment tends to be more profitable in export industries and less profitable in import-competing industries than would be desirable from the narrow nationalistic point of view."[5]

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1. Discussed previously under market imperfections. See especially C.Wolf,Jr., op.cit.
2. For example, an attempt to construct an input-output table for Tanganyika resulted in only 23 out of 306 cells being filled with significant coefficients. G.E. Eleish, "The Input-Output Model of a Developing Economy: Egypt"; in T.Barna (ed.), Structural Interdependence and Economic Development; MacMillan; New York; (1963). In fact, Eleish recommends that indeces based on structural interdependence be employed as a definition to distinguish between "developing" and "highly underdeveloped" economies. ibid., p.203.
3. Compare H.W. Singer, "The Distribution of Gains Between Investing and Borrowing Countries"; American Economic Review Proceedings; Vol.40; (1950); pp.473-485.
4. For example, see Lewis, "Development Planning"; op.cit., pp.38-55.
5. Scitovsky, "Two Concepts of External Economies"; op.cit.,p.307.

B.3.(b) The "Infant Industry Argument"

The infant industry argument has a long history in economic analysis; while usually being attributed to Freidrich List, it was clearly implicit in the policies of the Mercantilists.[1] The argument has elements both of dynamic externalities and of economies of scale.[2] Time may be required for factor supplies to a new industry to become established in a dependable manner, and to be of adequate quality; raw materials, manpower and distribution outlets may have to be developed, and credit facilities established. The general development of infrastructure in the economy, may also act to reduce costs to the industry. On the other hand, the initial size of the market may retard operations at optimum levels, and increasing returns may appear with the growth of the market, so that the industry may, in time, become competitive internationally. While calculations of private profit in such cases may not attract investments, government may find it appropriate to temporarily subsidise infant industries, when important externalities derive from them, or when the social rate of discount is below the marginal private internal rate of return.[3]

B.3.(c) Objectives of Development Planning

> "Consumption is the sole end and purpose of all production; and the interest of the producer ought to be attended to, only so far as it may be necessary for promoting that of the consumer. The maxim is so perfectly self-evident, that it would be absurd to attempt to prove it." [4]

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1. See, for example, P.W. Van Hornick, "Austria Over All, If She Only Will"; (1684) Reprinted in K.W. and L.L. Kapp, History of Economic Thought; Barnes and Noble; New York; (1949); pp.47-63
2. W.A. Lewis, "Development Planning"; op.cit., p.34.
3. See following discussion on social vs. private time preferences.
4. Adam Smith, Wealth of Nations; Modern Library ed., Random House; New York; (1937) p.625.

"Consumption - to repeat the obvious - is the sole end and object of economic activity." [1]

Acceptance of the above positions, still leaves some important problems of defining a social welfare function unsolved, principally: i) how consumption is to be distributed over time; (ii) how consumption is to be distributed among individuals, at every point in time; and, (iii) how consumption is to be distributed among different goods and services at every point in time. These questions are partly ethical in nature, and must ultimately be decided by the political process. A development plan specifies these decisions in the form of the objectives of the plan, their relative weights and their constraint levels. The principal objectives of planning may be described under the following categories:[2]

1. To increase consumption of goods and services per capita. In this study, unless otherwise specified, the population growth rate is assumed predetermined, or exogenous to the planning model, so that this objective effectively becomes: to increase the level of aggregate consumption of goods and services. If the maximization of aggregate consumption were the sole objective of development planning, then the achievement of a Pareto optimum would be consistent with the maximization of social welfare.[3] Aggregate consumption benefits from a project should measure consumers' willingness to pay for the

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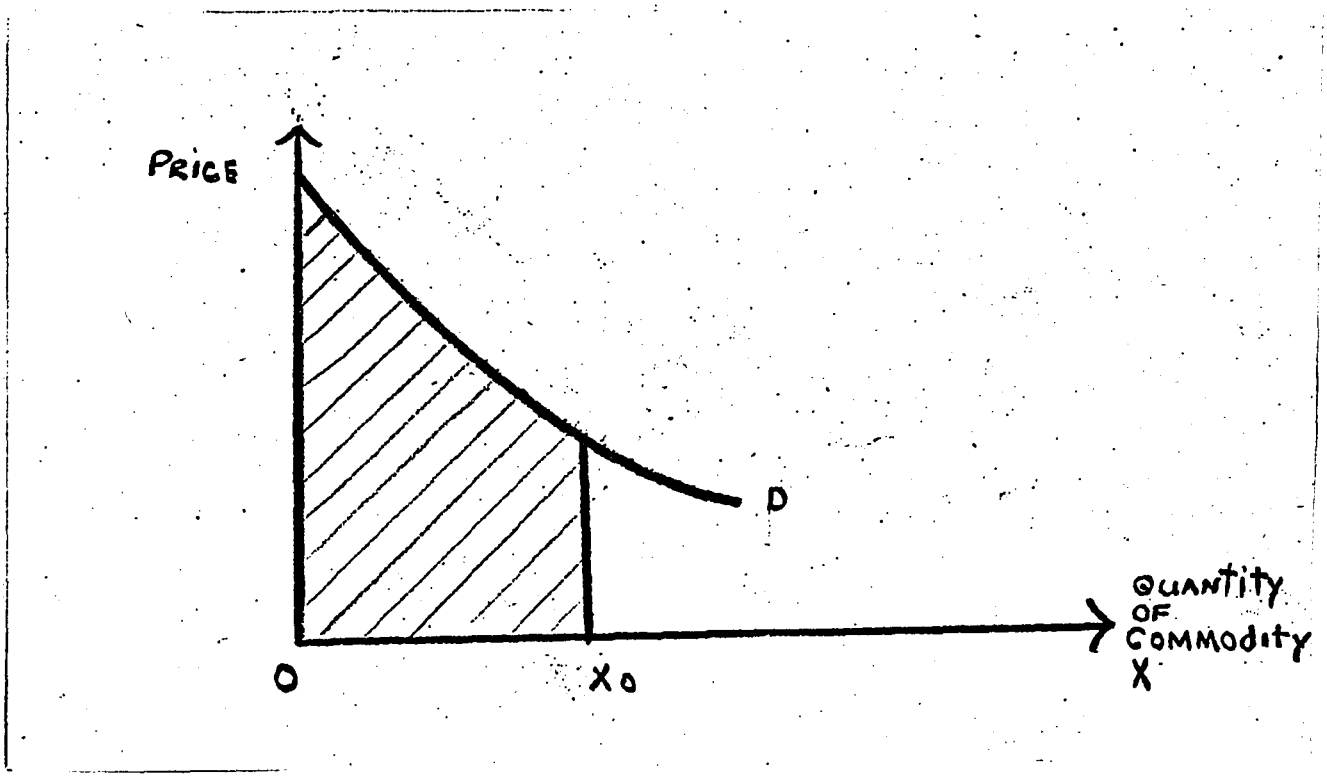
1. J.M. Keynes, The General Theory; MacMillan & Co; London; (1960) p.104.
2. Compare lists of objectives of development planning in E.P. Holland with R.W. Gillespie, Experiments on a Simulated Underdeveloped Economy: Development Plans and Balance-of-Payments Policies; The Massachusetts Institute of Technology Press; Cambridge, Mass.; (1963) p.4 and S.A. Marglin, Public Investment Criteria; op.cit., pp.19-23.
3. O. Eckstein, op.cit., pp.56-85. This assumes that the market rate of interest fully reflects social time preference, and that private and social risks are identical; see following section for fuller discussion of these problems.

output, under the assumption of 'consumer sovereignty'.[1] Willingness to pay may be approximated by the area under the market demand curve.[2] Thus, in the figure below, consumers' willingness to pay for quantity Xo may be measured by the shaded area.[3]



1. A. Maas and others; Design of Water Resource System; op.cit.,pp.22-28
2. This assumes constant marginal utility of income. Compare with I.M.D. Little, Critique of Welfare Economics; op.cit., Chapter 10.
3. Complications arise when the output of a project does not completely go to consumption; see discussion of this problem in following, as well as measurements of costs in non-optimal situations.

2. Redistributive Objectives. In a highly industrialized country like the United States, where government projects are effected for marginal adjustments in the market economy, and where fiscal measures can generally fulfil distributional objectives, project evaluation may be pursued without explicit consideration of redistributive objectives.[1] In low-income countries, however, an individual project may have a substantial impact on the economy, and the scope of fiscal or pricing policies for redistributive purposes may be severely limited by social and political factors.[2] There are also important economic considerations: manipulation of prices may result in mal-allocation of resources, when prices are caused to differ from marginal costs; and the application of taxes (other than lump sum taxes, which are politically the most difficult to impose) will tend to produce dis-incentive effects.[3] Thus considerations of redistribution of wealth among individuals, groups and regions will, generally, have to play an important role in decisions to allocate investment resources.

3. To satisfy 'merit-wants'. Professor Musgrave has defined merit wants as special instances when"...public policy aims at an allocation of resources which deviates from that reflected by consumer sovereignty."[4]

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1. See previous footnote, Page 22, No.1.
2. See W. Heller, "Fiscal Policies for Underdeveloped Economies"; in United Nations, Taxes and Fiscal Policy in Underdeveloped Countries; United Nations; New York; (1954); pp.1-22; reprinted in B.Okun and R.W. Richardson (eds.) Studies in Economic Development; op.cit., pp.448-476; especially pp.464-466. Also O.Eckstein, op.cit.,p.83; G.M.Meier, in idem (ed.) Leading Issues in Development Economics; Oxford University Press; New York; (1964) pp.127-129; and S.A. Marglin, Public Investment Criteria; op.cit., p.21.
3. Heller and Marglin, ibid.
4. R.A. Musgrave, op.cit., p.9 and also pp.13-14.

Common examples of merit wants are free school luncheons, subsidised low-cost housing, free or subsidised education, and limitations or regulations on the consumption of alcoholic beverages and narcotics.

4. To limit dependence on foreign aid.[1] This objective frequently derives from political considerations;[2] but the fact that aid volume is highly uncertain and, therefore, makes development planning unreliable, when there is heavy dependence upon aid is another important consideration.[3] A project's benefits with respect to this objective may be measured by the value of its contribution to exports or import substitution less the value of the import requirements for the initial investment and of operating inputs.[4]

Thus ends the list of categories of the objectives of development planning considered in this study.[5] It should be noted that, in general, there is imperfect complementarity between these objectives, so that no single one of them may be considered as an adequate index of social welfare (or economic development); when society is operating on its social welfare frontier, a marginal increase in any objective may require trading-off some amount of the others. Thus, for example, increasing aggregate consumption may have to result in some sacrifice

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1. Compare with W.W. Rostow's definition of "self-sustaining growth", op.cit., pp.39-40.
2. See, for example, W.A. Lewis, Development Planning; op.cit., p. 143.
3. The uncertainty associated with United States aid has been particularly evident in the latest two or three years. See following section regarding the implications deriving from uncertainty.
4. Compare with H.B. Chenery, op.cit.
5. A frequently cited objective that does not appear here is the reduction of unemployment and underemployment. See, for example, Holland and Gillespie, op.cit. However, unless unemployment is considered politically or socially undesirable, per se, this objective can adequately be represented within the aggregate consumption and redistributive objectives.

of the redistributive objective, or of merit wants, or of independence from foreign aid.

A second point to note is that the fulfillment of the objectives is not expected to occur instantaneously but in a gradual development over time. There will thus be a second dimension of choice when the satisfaction of some level of an objective in the present may require a sacrifice in the level of that or some other objective in the future. It is these problems of intertemporal welfare considerations that provides the subject of the next section.

B.3.(d) Intertemporal Comparisons of Welfare

As both the benefits and the costs of a project extend over a period of time, some basis for comparison of effects at different points in time is required. As has been previously outlined, the weighting of contributions to objectives at different points in time entails the same methodological procedure as the relative weighting of different objectives at the same point in time; and the weighting may equally be performed explicitly or, implicitly by setting constraint levels on the attainment of objectives for the different time periods. Ultimately, government-imposed value judgements - those that are expressed in the social welfare function - will have to determine the intertemporal comparisons of the various objectives of social welfare.[1] This section will attempt to clarify the considerations that enter into the interpretation of the social welfare function with regard to the selection of intertemporal weights.

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1. See A.P. Lerner, op.cit., pp.262-3 and, J. de V. Graaff, op.cit., pp. 99-105.

Under perfect competition, profit maximizing firms will hire resources until the value of the marginal product of the resource is equal to its price; in the case of capital, capital will be hired by the firm until its marginal productivity (the marginal efficiency of capital) equals the interest rate. The supply of savings, and investment demand will be equated at the equilibrium interest rate, and an optimal allocation of capital may result, provided that certain conditions obtain.[1] However, the resultant allocation of resources may not be optimal in a strict Paretian sense, since current saving and investment decisions will affect the welfare of future generations, whereas the preference functions of these future individuals will not be represented in the current capital market.[2] A second objection to the use of the market rate of interest to represent social time preferences suggests that collectively individuals are concerned with the welfare of future generations and would discount future consumption at a lower rate, were it not for the atomistic organization of the market which allows very little significance to the preferences of any individual.

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1. No direct interdependence, no indivisibilities, optimal allocation of resources initially and over time as a result of investment. Compare O.Eckstein, op.cit., pp. 56-85; especially pp. 57-59. However, these results are limited to the static analysis. When 'dynamic' external economies obtain, the market mechanism ceases to provide the information for optimum investment decisions. See previous discussions.

2. See Graaff, op.cit., Chapter VI; O.Eckstein, op.cit., p.57; A.K. Sen, Choice of Techniques; An Aspect of the Theory of Planned Economic Development; Basil Blackwell; Oxford; (1962; p.83.

> "...because of ... altruistic external effects, a political distillation of individual time preferences for consumption over investment may well be different from a market distillation of these preferences, and may be preferred by each to the market distillation."[1]

The use of the market rate of interest for purposes of intertemporal comparisons is confronted by the reality that capital markets function with the simultaneous use of several rates, and that the identification of the appropriate rate becomes a meaningless task, as the following 'quote within a quote' emphasizes.

> "His [K.E. Boulding's][2] main contention surely is invincible: the search for a 'pure' interest rate in abstraction from 'risk, liquidity, convenience, etc.' is meaningless, 'a search [in a dark room] for a black cat that isn't there.'" [3]

Prior to proceeding with the considerations that enter into intertemporal comparisons, it should first be established that future benefits should be discounted.[4] On the presumption that development planning proves successful, and that some economic development will

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1. A. Maas and others, Design of Water Resource Systems; op.cit.,p. 48; Prest and Turvey, op.cit., p. 169; A.C. Harberger, op.cit., p. 140, rejects this latter argument. Also S.A. Marglin, "The Social Rate of Discount and the Optimal Rate of Investment", Quarterly Journal of Economics; Vol.77; (February 1963); pp. 95-111.
2. K.E. Boulding, "M.Allais' Theory of Interest"; Journal of Political Economy; Vol.59; (February 1951).
3. G.L.S. Shackle, "Recent Theories Concerning the Nature and Role of Interest"; American Economic Association and Royal Economic Society Surveys of Economic Theory; Vol. 1; p. 141.
4. For an excellent survey of the Neoclassical literature of the intertemporal problem, see R.E. Kyenne, The Theory of General Economic Equilibrium; Princeton University Press; Princeton, New Jersey; (1963); Chapter 4.

occur,[1] a sufficient argument for discounting future benefits is provided by diminishing marginal utility. Following is a presentation of this case by Professor A.K. Sen.

> "The facts that tastes and preferences change and needs grow over time as well as that interpersonal comparison is not quite valid, lead to a great many difficulties (logical and practical) which make the application of this principle rather debatable. But there seems to be a common-sense case for not ignoring this tendency altogether, especially when we are considering underdeveloped economies rising from the bare subsistence level to some more tolerable level of economic existence." [2]

Thus some form of discounting procedure[3] must be applied to future benefits, and the market mechanism will not provide adequate information for the determination of discount rates[4] for planning purposes. In order that the exposition may be presented in a manageable form, the following discussion of intertemporal investment criteria will be limited to the aggregate consumption objective only. In addition

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1. In the context of this study, a definition of economic development which employs value judgements of the Paretian type may be applied. Thus economic development may be said to occur when at least one of the specified objectives of the social welfare function has attained a higher level of performance while none of the other objectives have declined. Compare with S.A. Marglin, Public Investment Criteria;op.cit., pp. 37-39.

2. A.K. Sen, op.cit., p.84; O.Eckstein, op.cit., p. 76, develops a similar argument. See also, S.A. Marglin, Public Investment Criteria; op.cit., p. 47. Other arguments for discounting future benefits are essentially related to the problem of uncertainty, of which more will be said in following.

3. Explicitly by specifying discount rates, or implicitly by specifying constraint levels for the objectives at different times. The following will assume, for expositional purposes, that the former method is employed.

4. As has already been mentioned, there is no logical reason why a different value for discount rates should not be applied in every period. In addition, each objective should probably be discounted at a different set of rates. Compare with S.A. Marglin, Public Investment Criteria; op.cit., p. 67, f.n.1.

the exposition will assume a single social time preference rate of discount.[1]

When there are significant departures from the competitive model in the economy, the marginal rate of return to private investors will differ from the marginal contribution of private investment to aggregate consumption (the marginal rate of return of aggregate consumption.)[2] When an investment contributes a greater than marginal quantity to the market supply of a given commodity, aggregate consumption benefits (in the form of consumers' surplus) created will exceed the revenue to the producer.[3] Furthermore, when resources are not fully employed (e.g. labour) a gap between their prices and their marginal productivities reflects a divergence between private costs and social opportunity costs. In addition, the government will arrive at a social time preference rate of discount for aggregate consumption benefits from independent considerations.[4]

The simultaneous existence of these different rates (of discount and of return) in a nonoptimal situation, is the critical aspect of the intertemporal criterion problem.[5] On the one hand, when public projects displace private investment, the opportunity cost (in terms of aggregate consumption benefits foregone) of these displaced resources must be discounted at the social discount rate. On the other hand, when a part of the aggregate consumption benefits that result from a project are reinvested in the private sector, these must be revalued. I quote Professors Prest and Turvey's concise summarization of the problem:

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1. Compare Harberger, Eckstein, Marglin, op.cits.

2. Intertemporal problems will be generally discussed in the following only with respect to the aggregate consumption objective for purposes of simplifying the exposition. Intertemporal problems with respect to the other criteria would require fundamentally similar considerations.

3. See A. Maas, et.al,op.cit., pp. 55-58., and previous discussions.

4. These are discussed in following.

5. Compare Prest and Turvey, op.cit., pp. 158-9.

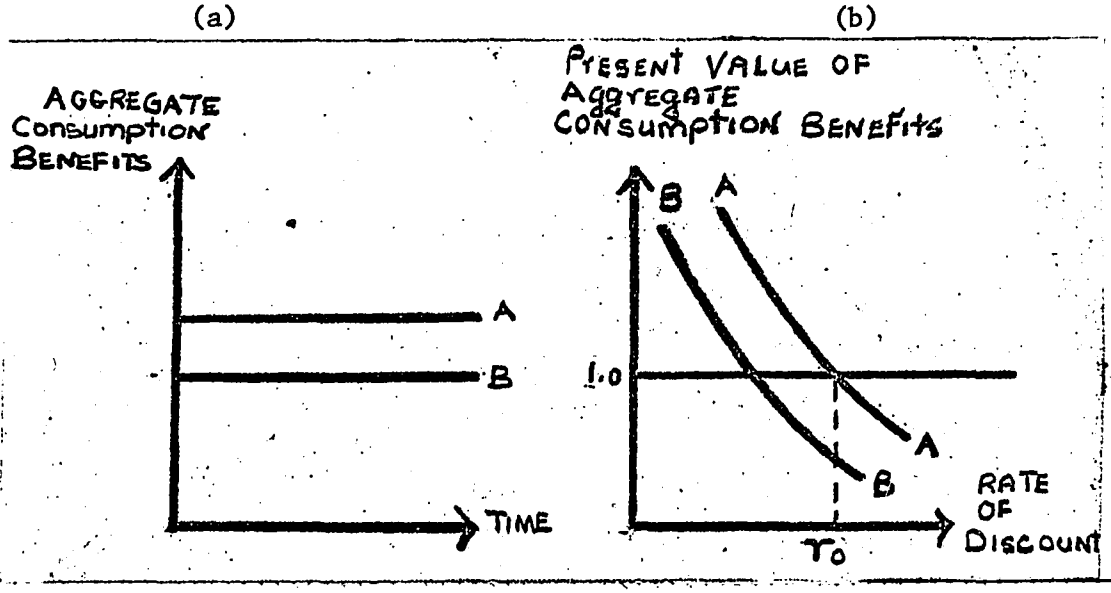
> "...the conditions for a welfare maximum are not likely to be fulfilled throughout the economy. If they were, and so resource allocation were optimal, the marginal social rate of time preference and the (risk-adjusted) marginal social rate of return from investment would coincide. A single rate of interest would then serve both to compare benefits and costs of different dates and to measure the opportunity cost of private investment which is displaced by the need to provide resources for the projects in question. As things are, however, no single rate of interest will fulfil both functions simultaneously; in a non-optimal world there are two things to be measured and not one." [1]

In the remainder of this section, I will, accordingly, proceed to examine separately the social time preference rate of discount and the social opportunity cost of capital.

(a) The Social Time Preference Rate of Discount.

The choice of the social time preference rate of discount for the aggregate consumption objective, will determine the pattern of the benefit streams of projects which are selected. Figure 7 illustrates

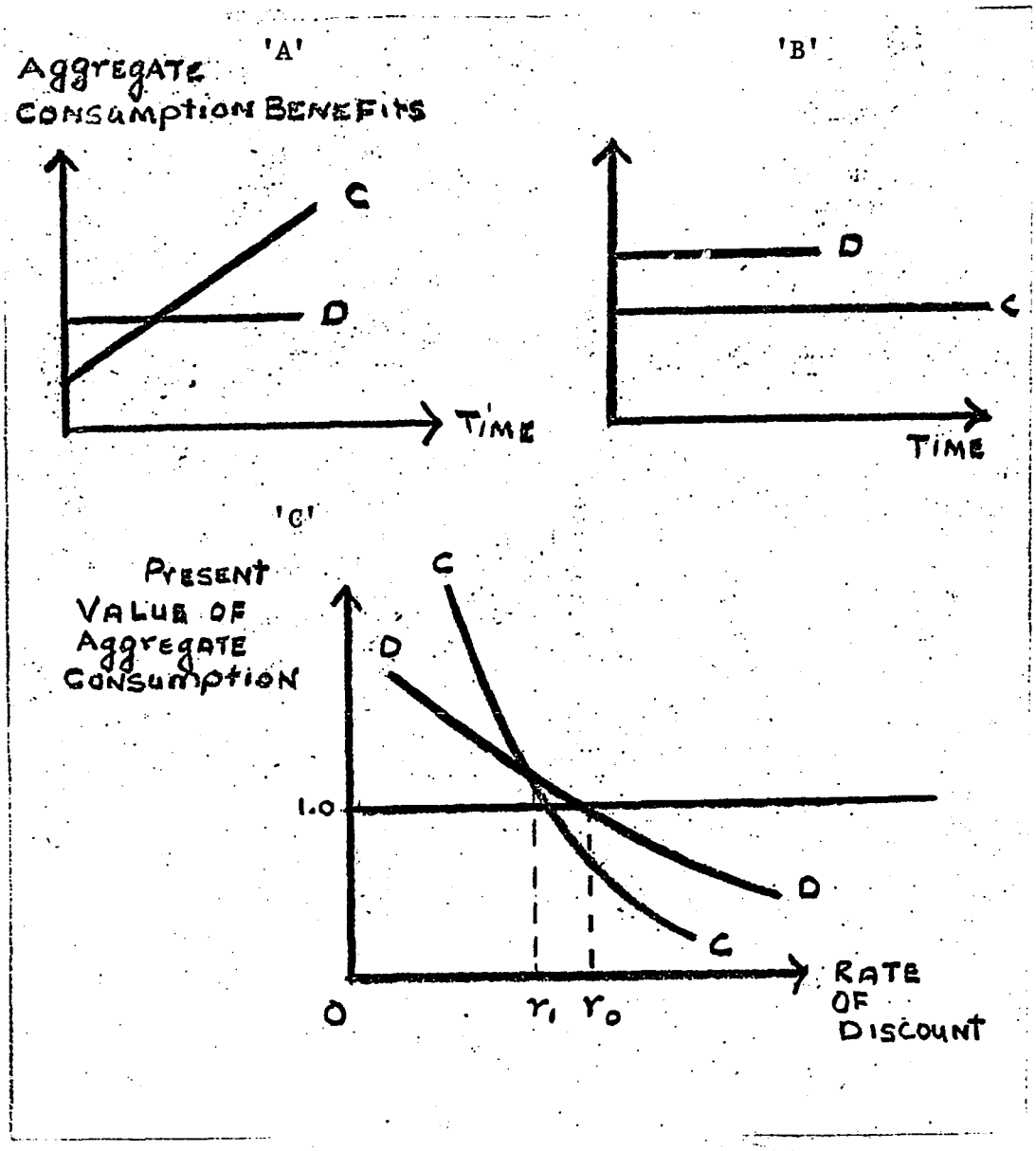
Figure 7



1. Prest & Turvey, op.cit., p. 158

the benefit streams of two independent projects with unit opportunity costs (in terms of aggregate consumption foregone). This represents a situation of 'dominance' in which project A is superior to project B by all criteria. Note, however, that the choice of discount rate retains some relevance even in this case, since at rates higher than 'r_o' neither of the projects yields exceeds its costs, so that both would be rejected.

Figure 8



In Figure 8, the selection of projects is a more difficult matter. Projects C and D in both 8(a) and 8(b) illustrate two typical patterns of benefit streams against which discount rates discriminate in the same manner, as illustrated in 8(c). [1] Again, at rates higher than 'r_0', both projects will be rejected. However, at rates which are less than 'r_1', project C will be preferred; at rates which are higher than 'r_1', project D will be preferred.

To summarize, the choice of a 'high' social time-preference rate of discount will discriminate against projects with long gestation periods, low initial yields and longer lives, in favour of projects with short gestation periods, high initial yields and shorter lives; and vice-versa, for low rates. The broader interpretation of these results is that the choice of the social rate of discount implies a choice of the growth path for the economy: [2] a high rate of discount for future consumption implies less willingness to give up present consumption to investment so that a slow and gradual growth path results; a low rate will favour higher levels of investment and a growth path which rises very slowly at first, but then much more steeply after the investments begin to provide their pay-offs. (See Figure 9 on next page.)

If the aggregate consumption objective was the only objective in the social welfare function, the interest rate which will provide the optimal growth path could be derived, from given initial conditions. [3]

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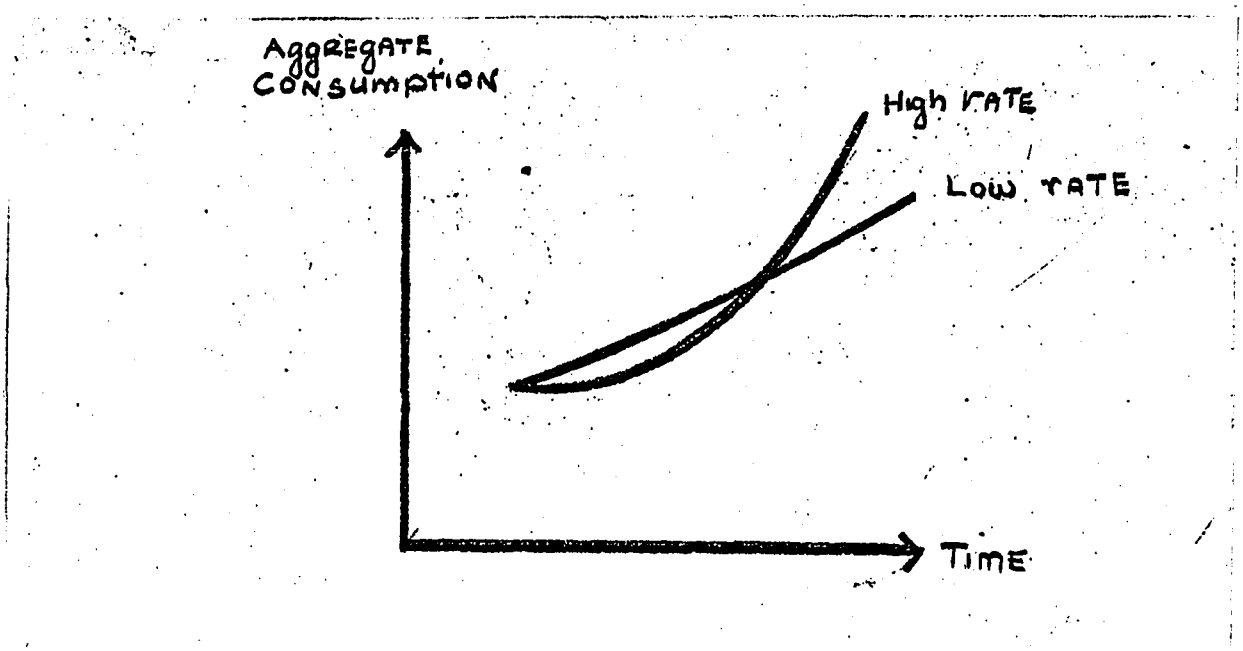
1. Compare with S.A. Marglin, Public Investment Criteria; op.cit.,pp. 64-66.
2. Compare with O.Eckstein, op.cit. In the competitive model, however, growth path does not present a problem: an optimal growth path will result from the maintenance of Pareto efficiency at all points in time. See F.M. Bator, "On Capital Productivity, Input Allocation and Growth"; Quarterly Journal of Economics; Vol.71; (February 1957); pp. 86-106; p.105; and A. Maas and others, op.cit., pp. 58-59.
3. See O.Eckstein, op.cit.

Figure 9



Unfortunately, in the present context of a social welfare function with multiple objectives, there can be very little guidance to the precise level of the discount rate. Professor Marglin provides the following limited guidance to the relationship between the social discount rate ($\bar{r}$) and observable rates of capital productivity: "$\bar{r}$ will be greater or smaller than the marginal rate of return of consumption to investment according to whether the over-all rate of investment is judged smaller or greater than optimal in terms of the aggregate consumption objective. (Even this little cannot be said about the relationship between $\bar{r}$ and [the marginal private rate of return])." [1]

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1. S.A. Marglin, Public Investment Criteria; op.cit., pp.54-55.

(b) The Social Opportunity Cost of Public Investment

In evaluating the social opportunity cost of public investment, a few fundamental considerations must be observed. With respect to the aggregate consumption objective, the social opportunity cost of public investment must include the direct reduction in private consumption which the utilization of additional resources for public investment entails, plus the present value of the consumption stream resulting from displaced private investment. To the extent that public investment employs resources that would have otherwise remained idle, opportunity costs will be correspondingly lower.

A second major consideration requires that adjustments be made for reinvestment of consumption benefits. Thus if the public project that is being evaluated is a steel mill, the part of its output that enters into the fabrication of machines to be employed in the private sector, cannot be counted as aggregate consumption benefits directly; but only indirectly, in the form of the present value of the aggregate consumption stream of benefits produced by the machine, which can be attributed to its steel input.

In the remainder of this section, some simple models, that have been developed by Professor Marglin[1] to illustrate the method of calculation of social opportunity costs, will briefly be summarized. The pattern of presentation of the problem only with respect to the aggregate consumption objective will be continued as before; the presentation must be viewed as illustrative of the type of considerations that

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1. S.A. Marglin, "The Opportunity Cost of Public Investment"; Quarterly Journal of Economics; Vol.77; (May 1963); pp. 274-289 and Public Investment Criteria; op.cit., pp. 54-69.

in general, must be applied with respect to all objectives.

(i) Opportunity cost of public investment, with full employment (a).

$$a = \theta \cdot P/\bar{r} + (i - \theta) \quad ;$$

where,

θ = the proportion of private investment displaced per 'dollar' of public investment;

P = annual rate of a perpetual consumption stream that results from the investment of one 'dollar' in the marginal private investment;

$\bar{r}$ = social time-preference rate of discount of aggregate consumption.

Here, $(\theta \cdot P)$ represents the annual value of the perpetual consumption stream displaced per 'dollar' of public investment. This is divided by $\bar{r}$ to yield the present value of the perpetuity. $(1-\theta)$ represents the reduction of current consumption resulting from one 'dollar' of public investment.

(ii) Opportunity cost of unemployed labour (w*), with wages completely consumed,

$$w^* = (\theta \cdot P/\bar{r} - \theta)w \quad ;$$

where,

w = the money wage.

This model assumes that a proportion of the increased consumption of the previously unemployed labour (θ), is provided by a reduction in resources entering into private investment; the remainder is transferred from other consumers. Thus the first term in parentheses represents the reduced consumption flow from private investment; the second represents the addition to current consumption.

(iii) Shadow price of output (p*), when a proportion (μ) of the output is reinvested in the private sector.

$$p^* = [\mu \cdot P/\bar{r} + (1 - \mu)]p \quad ;$$

where,

p = willingness to pay of private consumers per unit of output. In this model, (μ·p) is the annual value of the perpetual consumption stream resulting from the reinvested portion (μ) of each 'dollar's worth' of output.

The result of the separation of the social time-preference rate of discount from the social opportunity cost of public investment permits the evaluation of the aggregate consumption benefits that derive from a project (A_1) in the following form:

$$A_1 = \sum_{n=1}^{T} \frac{B_n}{(1+\bar{r})^n} - a \cdot K \quad ;^1$$

where,

B_n = aggregate consumption benefits derived from the project in year n;

K = the investment cost of the project (applied instantaneously) for simplicity); and,

T = life of the project in years.

Marglin illustrates an application of this "social-rate-cum-opportunity-cost" criterion which demonstrates that "the cutoff (marginal) rate of return for public investment projects vary inversely with the projects economic life", [2] when p is greater than $\bar{r}$. He explains the

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1. Compare with S.A. Marglin, Public Investment Criteria; op.cit., p. 54.

2. ibid., p. 61.

significance of this as follows:

> "If economic merit is judged in terms of the social rate of discount, direct use of P as a discount rate introduces undue discrimination against capital-intensive or durable projects as a consequence of trying to ensure that public investment is at least as meritorious as the alternative private economic activity. Evaluation of the present value of benefits at the discount rate $\bar{r}$ and of capital costs at a .... introduces no such bias in accomplishing the same goal of equalizing the marginal effectiveness of all kinds of investment."[1]

Values A_2, A_3, and A_4 could similarly be obtained for the project's contributions to the other objectives of the social welfare function. Finally, a criterion for project evaluation could be constructed requiring that the set of projects selected maximize the following expression:

$$A_1 + A_2 \cdot w_2 + A_3 \cdot w_3 + A_4 \cdot w_4 \quad ;$$

where the w's represent the relative weights that have been assigned to the respective objectives of the social welfare function.[2]

B.3.(e) Uncertainty

The concept of uncertainty may be distinguished from that of risk by defining risk as pertaining to situations the outcomes of which have a known probability distribution; under uncertainty, complete information regarding possible outcomes is not available. [3] Thus, for a given risky outcome, an actuarial value can be assigned, and private and social

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1. S.A. Marglin, Public Investment Criteria; op.cit., p.63.
2. Compare with United Nations (ECAFE), Programming Techniques for Economic Development; op.cit., pp. 35-39; and S.A. Marglin, Public Investment Criteria; op.cit., p.68.
3. Compare with F.H. Knight, Risk, Uncertainty and Profit; (reissued London, (1933)).

risk will be equal.[1]

Uncertainty is a "pervasive and fundamental" [2] aspect of investment decisions which derives from two types of sources; erroneous economic forecasting, and from inherently unpredictable phenomena like wars, international conditions, natural disasters, or technological breakthroughs.[3] With respect to uncertainty, it may be argued that in an economy in the process of a rapid transformation, uncertainty associated with public investment may be less than that for a corresponding private investment: a planning authority may be expected to have superior information on matters such as future price movements, changes in technology, competitive or complementary investment plans, and government policies.[4]

The three procedures for correcting for uncertainty in project evaluation that were recommended in the Green Book,[5] continue to be employed;[6] conservative estimates of benefits and costs; conservative estimates of project life; and the addition of an uncertainty premium to the social discount rate. Professor Marglin contends that the "law of large numbers" tends to operate in a programme of independent government projects, so that the conservative treatment by analysts of

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1. Marglin argues that social costs will be less in such a case for a public rather than a private project, since government projects can be "self-insured", while private projects will generally require the establishment of insurance companies. Public Investment Criteria; op.cit., p.72, f.n.2.
2. A.Maas and others, op.cit., p.158.
3. A.K. Sen, op.cit., p.86.
4. J.P. Rosenstein-Rodan, op.cit., p.20.
5. U.S. Government, Federal Interagency River Basin Committee, Subcommittee on Benefits and Costs, Proposed Practices for Economic Analysis of River Basin Projects; Washington, D.C., (May 1950); pp.22-23.
6. Compare Prest and Turvey, op.cit., p.171 and O.Eckstein, op.cit., p.68 for discussions of the relative merits of these procedures.

project outcomes is unnecessary when overestimates will tend to be offset by underestimates.[1] There are two general reasons why this argument is not entirely satisfactory. In the first place, when there is a diminishing marginal utility associated with higher levels of attainment of the objectives of the social welfare function, the welfare loss from a shortfall will exceed the gain from an equal windfall.[2] Secondly, while in terms aggregates of the several welfare objectives there may be an offsetting tendency with respect to uncertainty, the offests will not occur with respect to the individual physical components.

> "...the failure of our plan in any one field may halt the general progress via the development of bottlenecks, however much we may over-fulfil our targets in some other lines."[3]

With respect to both risk and uncertainty, the following recommendations by Professor Eckstein appear to merit careful consideration for long-run development strategy:

> "Diversification of the economy and development of the home market are two of the most common methods for reducing the dispersion of possible outcomes."[4]

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1. S.A. Marglin, Public Investment Criteria; op.cit., p. 73.
2. Compare M.Friedman and L.J. Savage, "The Utility Analysis of Choices Involving Risks"; Journal of Political Economy; Vol.54; (1948) pp. 279-304.
3. A.K. Sen, op.cit., p.86.
4. O.Eckstein, op.cit., p. 59.

CHAPTER III

As outlined in the previous chapter, the aim of project evaluation is to maximize the social welfare function subject to the constraint imposed by the social transformation function; alternately, the problem may be described as the choice of an investment programme which maximizes social benefits. Thus the implied procedure is to examine every attainable combination of projects, and to select from among these, that programme which maximizes net social benefits. Unfortunately, in practice, limitations of time, data and personnel, as well as those imposed by the undeveloped state of our analytical techniques, do not permit such a procedure. Consequently, various criteria have been devised for the evaluation of individual projects in isolation from the overall programme, which might produce a 'first approximation' to the optimal programme.

In the first part of this chapter, itsshall be assumed that problems of measurement of benefits and costs have been resolved, in order to isolate the problem of selection of the appropriate mathematical form of the criterion. Five alternative formulations of criteria for eliminating undesirable projects from consideration for current construction and which also can provide a ranking for acceptable projects, will be described, and their respective, specific limitations will be considered. Then the problem of choosing the optimum date for initiating a project will be examined. Finally, the five criteria will be compared to determine their specific biases, and to prescribe conditions under which they may provide rankings of projects, which do not conflict with each other.

The second part of this chapter will survey the principal, specific criteria formulations that have been proposed for project evaluation in low-income countries. These will be described and then evaluated from the perspective of the framework suggested in Chapter II of this study. In the third section of this paper, the entire approach of evaluating projects on an individual basis, independently of the remainder of the investment programme, will be evaluated.

A. General Criteria Forms

1. Description and Limitations

(a) The Benefit-Cost Ratio

The benefit-cost ratio is the criterion recommended in the Green Book for the comparison of water-resource projects in the United States.[1] It may be defined as the ratio of the present value of total benefits to the present value of costs. The algebraic expression for the benefit-cost ratio is:

$$\sum_{t=0}^{T} \frac{B_t(1+i)^{-t}}{C_t(1+i)^{-t}} \quad ,$$

where,

B_t are gross benefits in period t,

C_t are total costs, (investment and operating costs) (including replacement) paid out in period t,

T represents the life of the project in periods, and

i represents the social rate of discount.

In applying this criterion, all projects having a benefit-cost ratio whose value is less than one, are 'eliminated,'[2] and the ranking of projects may be undertaken on the basis of the value of this ratio.[3]

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1. Subcommittee on Benefits and Costs, Proposed Practices....; op.cit., p.14.

2. 'Elimination' in this study is with respect to present construction. An 'eliminated' project may, nevertheless, be suitable for construction at some future date. The question of scheduling projects receives separate discussion elsewhere in this study. The critical benefit-cost ratio of one, is an analogue of the profit maximization condition: marginal revenue equals marginal cost. (Similarly with the other criteria.) Thus if for the marginal project, benefits equal costs, their ratio must be one. See O.Eckstein, op.cit., p. 73.

3. The legal requirements of cost-benefit analysis in the United States are only that projects be "justified", i.e., have a benefit-cost ratio greater than one; this was stipulated in the Flood Control Act of 1936. See O.Eckstein, op.cit., pp. 47-50. Thus its recommendation in the Green Book does not necessarily constitute an approval of its use as a ranking function.

An inherent bias in the benefit-cost ratio is that it discriminates against projects with high operating costs.[1] During the operation of a project benefits are being accrued at the same time as operating costs are paid out. It is the benefits net of costs at any point in time that should provide relevant information for project evaluation; otherwise special weight is attached to effects which from the perspective of the social welfare function merely constitute internal transfers.[2]

A second difficulty, inherent in all criteria which take the form of a ratio, receives particular emphasis from Professor McKean.[3] This is the fact that maximizing a ratio implies indifference to the scale of numerator and denominator.[4] This problem may lead to serious errors when comparisons of 'incompatible' projects are made: for example, whether to construct a large or a small dam at a particular location. The small dam may yield the higher ratio, yet the large dam may still prove to be desirable in comparison to other projects in the programme. In such cases, the 'simple' ratio criteria lead to incorrect decisions.[5] The

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1. This point will be elaborated in a following section.
2. Compare R.N. McKean, op.cit., pp. 108-113. However, as Professor Eckstein explains, "American budgetary practice is peculiar." The departments of the government are granted budgets which they are required to allocate in the most desirable manner, and revenues from a project are returned to the general funds of the Treasury and have no effect on the budget of the programme. See O.Eckstein, op.cit., p.63.
3. ibid, pp. 35-37; 97.
4. In the limiting case, maximizing the ratio would imply selecting projects whose costs approached zero - which would probably be projects with benefits which were also very small in absolute terms.
5. Another way to view this scale problem, is that ratio criteria implicitly assume constant costs obtain throughout the economy, as in the competitive long-run equilibrium condition. Essentially this is again the problem raised by indivisibilities. See R.N.McKean, op.cit., p.77, f.n.3

correct decision rule in incompatibility situations is to select the largest project so long as the incremental value of the ratio exceeds that of the 'marginal project' (i.e. the least desirable project) in the programme.[1] In the present example, this requires the subtraction of the present values of benefits and costs of the two projects respectively, and a comparison of the ratio of the differences with the ratio of the marginal project.

$$\frac{B_2 - B_1}{C_2 - C_1}$$

(b) The Internal Rate of Return

Many distinguished economists have proposed the criterion of the internal rate of return.[2] The internal rate of return is defined as that discount rate which will equate the present value of the net benefit stream to zero. Thus, utilizing the notation of the preceding discussion, r is the internal rate of return when,

$$0 = \sum_{t=o}^{T} \frac{B_t - C_t}{(1 + r)^t} \quad .$$

On the basis of this criterion, projects whose internal rate of return is less than the social discount rate are to be 'eliminated', and projects which have a higher rate are ranked as more desirable.

In the case of incompatible projects the internal rate of return provides an incorrect criterion(because of the 'scale' problem discussed in the preceding section), and Fisher's "rate of return over

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1. M.S. Feldstein and J.S. Flemming, "The Problem of Time-Stream Evaluation: Present Value Versus Internal Rate of Return Rules"; Bulletin of the Oxford University Institute of Economics and Statistics;Vol. 26; (1964); pp. 79-85; p.83.

2. See P. Masse, op.cit., p.29. Masse lists Bohm-Bawerk, Wicksell, G. Akerman, F.H. Knight, K.E. Boulding and F.A.Hayek.

cost" rule must be applied.[1] Fisher's rule is analogous to the incremental rule described as applicable for ratio criteria: the rate of return over costs is that rate which equates the present value of the stream of the differences of the net benefits of the two projects to zero. If this rate exceeds the social rate of discount, the project whose net benefit stream was subtracted, is rejected.

A second difficulty arises from the fact that if net benefits are negative during a period beyond the initial investment period, the internal rate of return will not be unique, and may even be imaginary.[2] Such cases may not be very common in practice,[3] but when Fisher's rule must be applied (to say, projects with different gestation periods), ambiguous results are not unlikely.[4]

Thirdly, when the social rate of discount varies over the life of the project, the comparison of the internal rate of return with any particular rate may be irrelevant.[5]

Finally, the use of the internal rate of return implies that net benefit streams are perpetually reinvested at the same rate. To quote Professor Turvey who refers to the internal rate of return as the "Stalinist maximand",

"It is the right criterion only when the maximand is

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1. I. Fisher, The Theory of Interest; MacMillan; New York; (1930) p.155. See also A.A. Alchian, "The Rate of Interest, Fisher's Rate of Return over Cost, and Keynes' Internal Rate of Return"; American Economic Review; Vol.45; (Dec. 1955); p.938.
2. See for example, J. Hirshleifer, "On the Theory of Optimal Investment Decision"; Journal of Political Economy; Vol.66; (1958); p.329; M.S. Feldstein and J.S. Flemming, op.cit., p.81; P. Masse, op.cit.,pp.21-23.
3. Examples of negative terminal benefits may be an open-pit mine which must be recovered and a nuclear installation which must be decontaminated.
4. See Feldstein and Flemming, ibid., p. 83.
5. ibid, p.82.

the rate of growth of assets, and all quasi-rents can be and are re-invested as they accrue in further projects with the same internal rate of return." [1]

(c) The Net Benefits Criterion

The majority of economists working in the area of project evaluation techniques prefer the net benefits form of criterion,[2] because it permits them to avoid the technical difficulties associated with the internal rate of return, as well as certain inadequacies of the ratio criteria. The incompatibility situation may not require special treatment[3] when the net benefits criterion is employed. Moreover, the net benefits criterion is the appropriate one for dynamic investment problems dealing with the temporal sequencing of projects.[4] The net benefits criterion may be defined as the present value of the time stream of benefits minus costs:

$$\text{Net benefits} = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+i)^t} \quad .$$

Projects for which net benefits are negative are 'eliminated', and ranking is based on the size of net benefits.

The circumstances when adjustments must be made to the net benefits criterion in the comparison of 'incompatible' projects occurs when projects have different economic lives and it is anticipated that at the end of the shorter-lived project a particularly favourable investment opportunity will be available.[5] Thus, for example, if the choice is

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1. R. Turvey, "Present Value Versus Internal Rate of Return, an Essay on the Theory of the Third Best; Economic Journal; Vol.73; (March 1963); pp.93-98;p.96.
2. See for example, P. Masse, op.cit., p.38; R.N. McKean, op.cit., p.97; A. Maas, et al., op.cit., p.22; M.S. Feldstein and J.S. Flemming, op.cit., R. Turvey, ibid,
3. See below.
4. See S.A. Marglin, Approaches to Dynamic Investment Planning; op.cit.,p12.
5. See Feldstein and Flemming, op.cit., pp.84-85.

between two power stations with lives of twenty and forty years respectively, and it is anticipated that after twenty years technological development of nuclear power stations will have made such dramatic progress as to significantly reduce the costs of power production, the net benefit stream of this future project should be added to that of the twenty-year option.[1] In addition to these problems associated with the comparison of projects of different lives, the net benefits criterion tends to overstate the value of large projects because of its indifference to the magnitude of costs:[2] resources allocated to a single large project on the basis of this criterion, may pre-empt the possibility of executing several smaller projects which when aggregated, result in greater net benefits.[3]

(d) The Capital Recovery Period

The capital-recovery period is a criterion which has received wide application by American businessmen and Soviet planners,[4] and variants of it have been proposed for project evaluation for economic development.[5] The capital recovery period may be defined as the time period required for the (undiscounted) stream of benefits minus operating costs to equal the initial capital cost of the project. In the following expression,

$$\sum_{t=0}^{T} (B_t - O_t) = K$$

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1. Otherwise, the net benefits criterion would tend to discriminate against the short-lived project.

2. If, however, there are no limitations on the resources available for public investment, the net benefits criterion is completely appropriate (if correctly applied for the comparison of projects of different lives), and all projects having positive net benefits would be executed. See R.N.McKean, op.cit., p.78.

3. See S. Enke, op.cit., p. 294.

4. See for example, R. Turvey, op.cit., p.99 and "Recommendations of the All-Union Scientific-Technical Conference on Problems Determining the Economic Effectiveness of Capital Investments and New Techniques in the USSR National Economy" (Jan. 1959); reprinted in F.H. Holzman (ed.), Readings on the Soviet Economy; Rand McNally; Chicago (1962).

5. See for example, A.K. Sen, op.cit., and W.Galenson & H.Leibenstein, "Investment Criteria, Productivity and Economic Development"; Quarterly Journal of Economics; Vol.69; (August 1955); pp.343-370

where K is the investment outlay and O_t is the operating cost incurred in period t, T will be the capital-recovery period. In its simplest form, this criterion simply requires the minimization of T. Its more sophisticated versions require the specification of a time horizon (a problem requiring essentially similar considerations to those of the specification of social discount rates),[1] which provides the 'elimination' criterion for projects possessing a longer capital-recovery period than the horizon.[2] Again, for incompatible projects, an incremental-rule is available requiring that the recovery period (T) for the increment of investment be less than the standard time horizon, where T is defined by

$$\sum_{t=0}^{T} [(B_t^1 - O_t^1) - (B_t^2 - O_t^2)] = K^1 - K^2 \quad (3)$$

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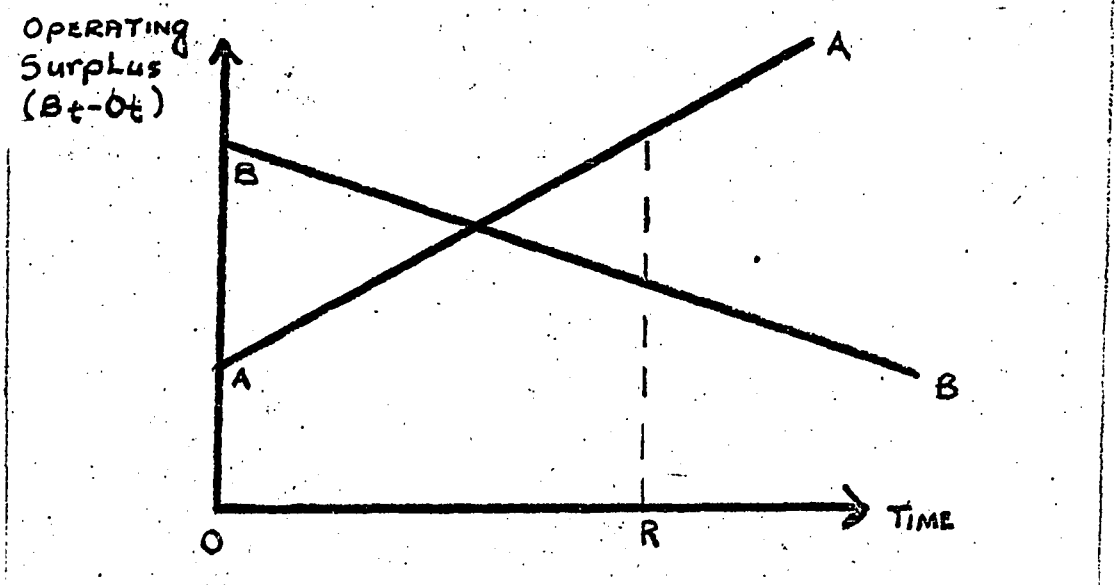
1. See, for example, A.K. Sen, op.cit., Chapter VIII.
2. The procedure in the Soviet Union was to specify different values for the time horizon for each branch of production. In 1960, "effectiveness ratios" (the inverse of the recoupment period) were set between 0.15 and 0.3 in the industrial sector, generally. Electric power and transportation had ratios as low as 0.1, however. See M. Dobb, "The Revival of Theoretical Discussion Among Soviet Economists"; Science and Society; (1960). Reprinted in H.G. Shaffer (ed.), The Soviet Economy; Meredith; New York; (1963).
3. "Recommendations of the All-Union.....", op.cit., presents the following criterion (in terms of the present notation):

$$T = \frac{K_1 - K_2}{O_2 - O_1} \quad .$$

However, the two projects under comparison are required to yield equal outputs, and furthermore, annual operating costs are assumed constant. The version of the criterion provided above will also reduce to this form, under the same assuptions.

The difficulty with the recovery (or recoupment) period criterion is that benefits accruing at all points in time prior to the time horizon are given equal weights, while all benefits beyond the time horizon receive zero weight. For example, in the accompanying figure, projects A and B have the same recoupment period, OR, and would therefore, ceteris paribus, be considered equally desirable. If however, there is a social time preference for current output, project B should be preferred because the bulk of its operating surpluses arrive earlier.[1] On the other hand, if, as in the figure, project A's benefits continue to increase beyond OR while those of project B continue to decline, A might be more desirable; but the criterion ignores this information.

Figure 10.



1. Professor Masse points out that this implies a 'straight line' procedure; op.cit., p. 35. R. Turvey says that Soviet railway engineers have been making clandestine use of interest rates since 1931, to escape such oversimplifications; op.cit., p.93 f.n.

(e) The Net Present Value to Investment Cost Ratio (ϕ) [1]

The ϕ criterion has been recommended for use under 'sub-optimization' conditions; i.e., when investment budgets are at a pre-defined, fixed level.[2] The ϕ criterion may be defined as,

$$\phi = \frac{\sum_{t=o}^{T} \frac{(B_t - O_t)}{(1+i)^t}}{K} \quad .$$

Projects having a ϕ value less than unity are 'eliminated',[3] and projects may be ranked as progressively more desirable as their ϕ value increases. The conventional incremental adaptation may be applied to this criterion when choosing between incompatible projects,[4] as follows:

$$\phi_{1,2} = \frac{\sum \frac{(B_t^1 - O_t^1) - (B_t^2 - O_t^2)}{(1+i)^t}}{K^1 - K^2}$$

As is the case with the net benefits criterion from which it derives, the ϕ criterion may discriminate against short-lived projects. If a 'better than marginal' investment opportunity is available upon the completion of the shorter-lived of two projects under comparison, the net benefit stream[5] of the future project should be added on. Professors Feldstein and Flemming

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1. The symbol ϕ will be used to represent this criterion.
2. J. Hirshleifer, J.C. de Haven and J.W. Milliman, Water Supply Economics, Technology and Policy; University of Chicago Press; Chicago; (1960); Appendix to Chapter VII. See also R.N.McKean, op.cit., p.37. Professor Chenery's SMP criterion is also a variant of this type. See H.B. Chenery, op.cit.; compare with O.Eckstein, "A Survey of the Theory of Public Expenditure Criteria"; in Buchanan, (ed.) Public Finances: Needs, Sources and Utilization; Princeton University Press; Princeton, N.J; (1961) p.461.
3. A ϕ value of unity can readily be confirmed as identical to a value of zero for the net benefits criterion.
4. See J. Hirshleifer, et.al, op.cit; and M.S. Feldstein and J.S. Flemming, op.cit., p. 83.
5. In this case, the investment costs of the future project should be counted as 'operating costs' for the presently considered project.

have stated this rule as follows:

> "Taking the present value of a specific future investment into account is justified only where one of a pair of incompatible projects does, and the other does not, preclude the exploitation of some specific future opportunity." [1]

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1. "The Problem of Time-Stream Evaluation", op.cit., p.84. See also M.S. Feldstein,"Net Social Benefit Calculations and the Public Investment Decision"; Oxford Economic Papers; Vol.16; (March 1964);

A. General Criteria Forms (cont.)

2. Dynamic Considerations

This section deals with sequential ordering of projects; it examines the considerations associated with the selection of an optimal pattern of construction dates, or in the technical language, the optimal 'assignment'[1] of projects. Dynamic project planning is a comparatively recently developed contribution to project evaluation.[2]

The criterion form employed in this analysis is 'net present value' of benefits over costs where only construction costs are counted as costs, so that the effect of varying the construction date may be isolated; operating, maintenance, and replacement costs are treated as 'negative benefits'.[3] The factors which cause the yield of a project to vary at different points in time are: its age, which affects its productivity; and the calendar date, which will result in varying demand conditions. With this information, the net present value of different projects, which may be constructed at different dates, and which compete for a given sequence of budgets, may be compared. A necessary condition for preparing such an analysis is that the projects be independent, in the sense that their costs and benefits are not affected by the dates of construction of the other projects in the programme.[4]

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1. This term derives from Linear Programming, which provides the solution technique for problems of a more complex nature than those illustrated in the following. See A.Maas, and others, op.cit., p.187.

2. The seminal contributions in this area are: A.S. Manne,"Capacity Expansion and Probabilistic Growth"; Econometrica; Vol.29;No.4; (October 1961); pp. 632-649; S.A. Marglin, Approaches to Dynamic Investment Planning; op.cit.;;and K. Arrow, "Optimal Capital Policy, the Cost of Capital, and Myopic Decision Rules"; Annals of the Institute of Statistical Mathematics; Vol; 16; Nos. 1 & 2; (1964); pp.21-30.

3. Compare S.A. Marglin, Approaches to Dynamic Investment Planning;op.cit., p. 5.

4. This, however, does not conform precisely with the conventional usage of the term 'independent projects'. Projects which are mutually exclusive (which must to some extent be true for projects competing for the resources of fixed budgets), are generally termed 'interdependent'. See, for example, R.N. McKean, op.cit., p.90.

The basis for the dynamic analysis lies in the fact that as the construction of a project is postponed, the present value of its construction costs decline, if construction costs do not increase over time. Thus, this type of analysis gains in importance in projects where construction costs are predominant and in projects which are very durable: water resource projects provide a good example. Professor Marglin is more emphatic:

> "Only in the case of independence of the benefit rate (demand) from calendar time - or, more generally, when benefits decrease over time - can we properly ignore future construction and decide simply whether a project ought to be constructed today."[1]

The problem may be formulated in the following manner: given a limited investment budget, assignment of projects should be based on losses in present value, from postponement; rather than on a comparison of present values for immediate construction.

Consider, for example, a project having a construction cost C (which remains invariable over time), and which yields an invariant annual net benefit (beginning immediately) of b, into perpetuity. If a discount rate of r is used, the present value of these benefits will be $B = b/r$. Therefore, the value of net present benefits will be B-C. Consider next the effects of postponing construction by n years. The present value of construction costs will have declined (a saving) by,

$$C - C(1+r)^{-n} = C[1 - (1+r)^{-n}] \quad ;$$

and the present value of benefits will have declined (a loss) by

$$B - B(1+r)^{-n} = B[1 - (1+r)^{-n}] \quad .$$

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1. S.A. Marglin, Dynamic Investment Planning; op.cit., p. 29.

Thus the gain in net present benefits from the delay is

$$(C-B)\ [1-\ (1+r)^{-n}\ ].$$

In the latter expression, the term in square parentheses will be positive whenever the discount rate is positive,[1] and will increase as n increases. Therefore, when C-B is positive, the delay in the construction of the project will result in a gain, which increases as n increases. Stated more generally, a project whose immediate construction is unfeasible (i.e., it results in a net present loss), should not be finally rejected (if its construction costs do not increase as its assignment is delayed and its benefits increase over time), but should be considered for assignment at some future date, when its net present value (today) would in fact be positive. This conclusion will also apply in cases where benefit streams and construction costs are more complex than in the above illustration; so that project planning should,optimally, consider the problem of choosing an assignment date as one of the variables, especially in cases where projects are durable.

A second illustration of the application of dynamic planning considerations may be provided by an example. The following table is reproduced from A. Maas, and others:[2]

Construction Periods

Projects	1961	1966
W_1	728.40	718.61
W_2	350.00	274.05

1. Actually, the term in square parentheses will also be positive for all r<-2, and for -1>r>-2 when n is an odd integer; but values of r in these ranges need not concern us.

2. Design of Water-Resource Systems; op.cit., p.186. The exposition of this example is presented in ibid, pp.184-188.

The two projects, W_1 (with benefits increasing over time) and W_2 (with constant benefits over time), both have construction costs of \$150, which is also the total size of the budgets for 1961 and 1966. The data in the matrix represents net present benefits (in 1961) from the projects when their construction is begun on the two dates. The static or "Myopia Rule" would choose project W_1 for immediate construction, and W_2 would be constructed in 1966, residually. However, it is apparent (to the far-sighted) that the other sequence (W_2 in 1961 and W_1 in 1966) yields a higher net present value, because of the lower deferral cost associated with W_1. Thus, the Myopia Rule would have led to the wrong decision.

Professor Marglin has derived the following general rule for the scheduling of projects,[1] which has been generalized by Professor Arrow.[2] If,

1. the costs of indivisible projects or increments are independent,[3]
2. marginal benefits do not increase with the scale of the project but do increase with time, and
3. gestation periods can be ignored,

the optimal sequence of projects (or increments) will result from their construction on the date when net present benefits are first positive, calculated on the (incorrect) assumption that the current benefit rate will continue indefinitely.

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1. S.A. Marglin, Dynamic Investment Planning; op.cit., pp. 22-25.
2. "Optimal Capital Policy...."; op.cit. The generalization is with respect to the choice of discount rates, when they vary over time. The correct procedure in this case is to, nevertheless, use the currently applicable rate to calculate net present value.
3. Professor A. Manne has dealt with this restrictive assumption. "Capacity Expansion and Probabilistic Growth"; op.cit.,When economies of scale are present, these must be balanced with interest costs and benefit loss to yield the optimal assignment date.

A. General Criteria Forms (cont.)

3. Comparison of Criteria Forms

The purpose of this section will be to examine the significance of statements such as the following, which are occasionally met in the literature:

> "...the Bureau of Reclamation and the Corps of Engineers are quite enthusiastic about benefit-cost ratios, while the Department of Agriculture has been very reluctant to have its projects judged in that way."[1]

In order to permit comparison of the ranking functions for the five criteria discussed in the previous section, the following simplifying assumptions will be made regarding projects to be compared: independence of projects;[2] the value of benefits and operating costs of a project will be the same for every year of the project's life; investment is an instantaneous process; and the social discount rate is constant over time.[3] The notation is as follows:

B = benefits per year;

C = costs per year, including charges on capital;

K = fixed investment;

O = operating, maintenance, and routine replacement costs per year;

i = social discount rate;

r = internal rate of return;

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1. O. Eckstein, Water Resource Development; op.cit., p.60.
2. The meaning of 'independence' in this context is that a project's cost and benefit streams are unaffected by whether or when any other project in the programme is executed.
3. These assumptions, the notation, the first equation to be derived, and the inspiration for the derivation of the remaining equations are all due to O. Eckstein, ibid, pp. 55-57.

T = life of project, in years; and

$$a_{iT} = \left[\sum_{t=1}^{T} \frac{1}{(1+i)^t}\right]^{-1} \cdot {}^{1}$$

With respect to a_{iT}, the effects of changes in its variables are noted: as i increases, a_{iT} increases; and as T increases, a_{iT} increases.

(i) The Benefit-Cost ($^{B}/_{C}$) ratio versus the Internal Rate of Return ($\underline{r}$)

$$\left(\frac{B}{C}\right) = \frac{B/a_{iT}}{O/a_{iT} + K} = \frac{B}{O + Ka_{iT}} \qquad (1)$$

The internal rate of return is represented in the following:

$$K = \frac{B - O}{a_{\underline{r}T}} \qquad (2)$$

$$\therefore B - O = Ka_{\underline{r}T}$$

$$\text{and} \quad B = K \cdot a_{\underline{r}T} + O. \qquad (3)$$

Substituting in (1)

$$\left(\frac{B}{C}\right) = \frac{O + Ka_{\underline{r}T}}{O + Ka_{iT}} \qquad (4)$$

Solving (4) for $a_{\underline{r}T}$,

$$a_{\underline{r}T} = a_{iT}\ \frac{B}{C} + \frac{O}{K}\ \left(\frac{B}{C} - 1\right) \qquad (5)$$

Substituting $^{B}/_{C} = 1$ in (5) yields,

$$a_{\underline{r}T} = a_{iT} \qquad (6)$$

Thus when $^{B}/_{C} = 1$, $\underline{r} = i$. Moreover, when i, T, O, and K are constant, (5) indicates that as $^{B}/_{C}$ decreases, $\underline{r}$ also decreases. We therefore conclude that all projects eliminated from consideration for present execution by the benefit-cost ratio will also be similarly eliminated by the internal rate of return.

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1. Values of a_{iT} are generally tabulated in actuarial tables under, "Annuity Whose Present Value is 1".

Equation (5) also indicates that cet.par., the two criteria will not rank projects having different lives in the same order. Consider two projects having r equal (and $\frac{O}{K}$ equal),

but $T_2 > T_1$.

Also $r > i$.

Then a_{rT} will increase by more than a_{iT}, [1] for the longer-lived project. Therefore, from (5), we see the B/C must increase as a_{rT} increases. Thus of the two projects which received equal rankings from the r criterion, the project with the longer life will have a higher B/C value. Thus the benefit-cost ratio is biased toward projects with long lives, relative to the internal rate of return.

Equation (5) also indicates that, cet.par., as the ratio O/K increases (and B/C is constant), a_{rT} and consequently r, increases. Thus we may also conclude that the internal rate of return criterion is biased toward projects with higher ratios of operating costs to fixed investment costs, relative to the internal rate of return. [2]

(ii) The Benefit-Cost Ratio (B/C) versus the Net Benefits Criterion (NB).

In the present context, net benefits are defined in the following manner:

$$NB = \frac{B - O}{a_{iT}} - K .$$

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1. Suppose, for example, $T_2 = T_1 + 1$.

Then $a_{iT} = \left[\sum_{t=1}^{T} \frac{1}{(1+i)^t} \right]^{-1}$, and $a_{i(T+1)} = \frac{}{\sum_{1}^{T} \frac{1}{(1+i)^t} + \frac{1}{(1+i)^{T+1}}}$

Now $1/(1+i)^{T+1}$ will be smaller, as i increases; and therefore, larger i values will cause a_{iT} to increase by more for every 'marginal' increase in T than would a smaller value of i.

2. Compare O.Eckstein, Water Resource Development; op.cit., pp. 55-65.

Solving this expression for B and substituting into the definition of B/C, yields the following relationship:

$$NB = \left[\frac{B}{C} = 1\right]\left[\frac{O}{a_{iT}} + K\right] . \quad (7)$$

We note that when $B/C = 1$, NB = 0; and that as the value of B/C falls below 1, the value of NB becomes negative. Thus all projects eliminated from consideration for present execution by B/C will be similarly eliminated by NB.

As to biases with respect to project life, we note from equation (7) that of two projects having equal B/C ratios, and different lives, the project with the longer life, cet.par., will yield a lower NB value. Thus the B/C ratio is biased toward projects with longer lives, relative to the NB criterion. We also note from (7) that, cet.par., the NB criterion is biased toward projects with higher initial investment costs (K), relative to the B/C criterion. Finally since

$$\frac{O}{a_{iT}} + K$$

is equal to the present value of the total costs of a project, we note from (7) that, cet.par., the NB criterion is biased toward projects with greater present values of total cost, relative to the B/C criterion.

(iii) The Net Benefit Criterion (NB) versus the Internal Rate of Return (r)

With the definitions given above, we may solve for (B-O) in the expression with r, and substituting into NB, the following equation is derived:

$$NB = K\left(\frac{a_{rT}}{a_{iT}} - 1\right) . \quad (8)$$

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1. The pattern of derivation for this equation (and those to follow) is similar to that of (5). It thus appears unnecessary to repeat the derivations in every case, for the purposes of the present study.

We note that when $\underline{r} = i$, NB=0; and that when $\underline{r}<i$, NB is negative. Therefore all projects eliminated from consideration for immediate execution by the NB criterion will also be similarly eliminated by the $\underline{r}$ criterion.

However, when $\underline{r}>i$, and two projects have equal $\underline{r}$ values but different T's, cet.par., the project with the greater T will have the greater NB value. Thus the NB criterion is biased toward projects with longer lives, relative to the $\underline{r}$ criterion. We may also note from (8), that the NB criterion is biased toward projects with higher K, relative to the $\underline{r}$ criterion.

(iv) The Benefit-Cost Ratio ($^{B}/_{C}$) versus the Recoupment Period ($1/\Psi$)

In the present context, the recoupment period is defined:

$$1/\Psi = \frac{K}{B-O} \quad \text{years;}$$

and the criterion is to minimize this value. However, in order to remain consistent to the pattern of the other criteria examined, our calculations proceed in terms of its reciprocal, Ψ, which is to be maximized. By solving this definition for B, and substituting in the expression for $^{B}/_{C}$, the following equation may be derived:

$$\Psi = a_{iT}\left(\frac{B}{C}\right) + \frac{O}{K}\left(\frac{B}{C} - 1\right) \qquad (9)$$

We note that when $^{B}/_{C} = 1$, $\Psi = a_{iT}$; so that the setting of standard (minimum) Ψ values (as was the procedure in the Soviet Union)[1] for comparison of projects with equal life spans,[2] is equivalent to choosing a social discount rate. Furthermore, we note from the expression for Ψ in (9) that

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1. See previous footnote under the discussion of the recoupment period.

2. We shall see, as this section develops, that the Ψ value is heavily biased in favour of durable projects.

Ψ is biased toward both more durable projects (longer life) and projects with higher O/K ratios, relative to the B/C criterion.

(v) The Internal Rate of Return (r) versus the Recoupment Period ($1/\Psi$)

By observing the established procedure we derive:

$$\Psi = a_{\overline{rT}} \quad ^{1.} \qquad (10)$$

We note that only different durabilities affect the relative rankings of the two criteria and that Ψ is biased to more durable projects relative to r.

(vi) The Net Benefits Criterion (NB) versus the Recoupment Period ($1/\Psi$)

By observing the established procedure, the following equation is derived:

$$NB = K\left(\frac{\Psi}{a_{\overline{iT}}} - 1\right) \qquad (11)$$

We conclude that the Ψ criterion is biased toward more durable projects, but also toward projects with lower initial investment outlay, relative to the NB criterion.

(vii) The Benefit-Cost Ratio (B/C) versus the Net-Present-Value-To-Investment-Cost Criterion (ϕ)

In the present context, the ϕ criterion is defined in the following manner:

$$\phi = \frac{\frac{B - O}{a_{\overline{iT}}}}{K}$$

By solving for B, and substituting in the expression for B/C,

$$\phi = \frac{B}{C} + \frac{O}{K}\left[\frac{B}{C} - 1\right]\frac{1}{a_{\overline{iT}}} \quad . \qquad (12)$$

We observe that when $B/C = 1$, $\phi = 1$, and that when B/C is negative, ϕ is also negative; so that all projects eliminated from consideration for

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1. This result may also be derived directly by noting that the expression for Ψ in (9) is identical to the expression for $a_{\overline{rT}}$ in (5).

immediate execution by the $^{B}/_{C}$ criterion will also be similarly eliminated by the ϕ criterion.[1] Moreover, we deduce that the $^{B}/_{C}$ ratio is biased toward more durable projects, and projects with higher $^{K}/_{O}$ ratios, relative to the ϕ criterion.

(viii) The Net Benefits Criterion (NB) versus the Net-Present-Value -To-Investment-Costs Criterion (ϕ)

By proceeding in the established manner we may derive:

$$NB = K(\phi - 1) \quad . \qquad (13)$$

Relative ranking on the basis of the two criteria is unaffected by varying project durabilities, and the NB criterion is biased toward projects with greater K, relative to the ϕ criterion.

(ix) The Internal Rate of Return (r) versus the Net-Present-Value-To-Investment-Costs Criterion (ϕ)

The following equation is derived:

$$\phi = \frac{a_{rT}}{a_{iT}} \quad . \qquad (14)$$

The only factor that will affect the relative ranking of the two criteria is the occurence of varying lives among projects; and the ϕ criterion is biased toward more durable projects, relative to the internal rate of return.

(x) The Recoupment Period ($^{1}/_{\psi}$) versus the Net-Present-Value-To-Investment-Cost Criterion (ϕ)

The following equation is derived:

$$\Psi = \phi \cdot a_{iT} \quad . \qquad (15)$$

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1. From this information and our previous results we may also deduce that all projects eliminated from consideration for immediate execution by ϕ will correspond to the projects similarly eliminated by the r and NB criteria.

From (15) we conclude that only varying lives can cause the relative ranking of projects by the two criteria to differ; and the Ψ criterion is biased toward more durable projects, relative to the ϕ criterion.

(xi) Summary of Results

The first result that we may report is that the criteria $^{B}/_{C}$, r, NB, and ϕ are perfectly compatible in the elimination from consideration for immediate execution of undesirable projects.[1] This fact, however, does not vitiate the efforts of the previous section: all projects that are not 'eliminated', will not necessarily be accepted.[2] It is true that if capital and all other resources have been correctly valued at their social opportunity costs, it would be desirable for the government to initiate all projects which these criteria indicate as 'justified':[3] since any justified project would represent a more desirable utilization of resources than available alternatives in the private sector. Unfortunately, the planning agency will generally not be able to execute all justified projects, because it may be constrained by budgetary limitations arising from the limited capability of its fiscal machinery.[4]

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1. Compare Prest and Turvey, op.cit., with respect to $^{B}/_{C}$, r, and NB.(p.175). We also showed that when all projects under comparison are of equal durability, a minimum value of $\Psi = a_{iT}$, will also 'eliminate' the corresponding set of undesirable projects.
2. Even in the United States, where the legal requirement of the evaluation exercise is only project 'justification', the relative ranking of projects nevertheless has an important influence on the selection decisions. See, e.g., O. Eckstein, Water Resource Development; op.cit., p. 48.
3. This statement contains very strong assumptions about the precision with which project evaluation can be carried out.
4. See, for example, W. Heller, op.cit. However, in some low-income countries where personnel limitations result in very few project studies, all justified projects may indeed by executed.

We may conveniently summarise the results of this section regarding the relative biases of the various criteria considered, in the following table; where the order (from left to right) in which the criteria appear indicates their relative biases toward the quality under consideration, and the enclosure of criteria in parentheses indicates no relative bias among the parenthesized criteria with respect to the quality under consideration.

Quality	Relative Bias
Longest life (T)	Ψ ; $^{B}/_{C}$; ($\emptyset$,NB) ; $\underline{r}$.
Highest K value	NB ; $^{B}/_{C}$; ($\underline{r}$,$\emptyset$,Ψ).
Highest (K/O) ratio	$^{B}/_{C}$; ($\underline{r}$,$\emptyset$,Ψ).
Highest total cost[$(^{O}/_{a_{iT}})$+K]	NB ; $^{B}/_{C}$..

From the table, we can deduce that equal project lives (T), equal initial investment costs (K), and equal ratios of operating costs to fixed investment costs ($^{O}/_{K}$) among all projects (it must be recalled that a critical assumption made in this section was that projects were independent), will provide the necessary and sufficient conditions for identical ranking of projects by all criteria.[1] The implication of these conditions is that the practical scope for 'partial' project evaluation techniques (i.e., techniques employed for the evaluation of single projects independently of the remainder of the investment programme), is limited[2] to the comparison of 'similar' (in all these dimensions) projects.

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1. The fulfilment of these conditions (four) among all projects, is sufficient to ensure that the total cost condition will also be observed. However, equal uncertainty should enter into such a list of conditions. Compare O. Eckstein, Water Resource Development; op.cit., p.55.

2. This implication is generally recognised by proponents of various project evaluation criteria. See, for example, H.B. Chenery, "The Application of Investment Criteria; op.cit; "Recommendations of the All-Union Scientific-Tehhnical Conference..."; op.cit; and O. Eckstein, Water Resource Development; op.cit., p.55.

To conclude this section on general criteria forms, their remaining social welfare implications will briefly be summarised. When limitations on the extent of public investment are imposed, some type of 'suboptimization' solution will generally be sought. Unless some 'higher order' criterion [1] can be used to determine the 'scale' of all projects (in which case the NB criterion will be appropriate), a criterion of the ratio form will have to be employed. The maximization of a ratio criterion implies that its numerator represents an index of social welfare, and the denominator represents the constraining resource.[2] In the $^{B}/_{C}$ criterion, it is the bundle 'present value of total costs' which is designated limitational; this tends to discriminate against projects with high operating costs. But operating costs which are simultaneously recovered are not social costs. In the remaining ratios, initial investment costs (K) are limitational, which implies that resources other than capital have a zero social opportunity cost.[3] This would be an appropriate assumption only if the government wanted to maximize benefits deriving from its own investments, rather than those of the whole economy. Thus social welfare implications are inherent in the choice of general criteria forms. In the following section we shall examine the social welfare implications of criteria which have been specifically formulated for the purpose of evaluating projects in the context of economic development.

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1. See R.N. McKean, op.cit., pp. 29-34.
2. See, for example, S. Enke, op.cit., pp. 293-5; and O.Eckstein, "A survey of the Theory of Public Expenditure Criteria"; op.cit., p. 452.
3. See, for example, S. Enke, ibid, pp. 294-295; and F.M. Bator, op.cit., p. 100.

B. Specific Criteria Forms for Economic Development

1. The Capital-Turnover Criterion

Professors Buchanan[1] and Polak[2] were among the first to recommend the maximization of the rate of turnover (i.e., the ratio of annual output to capital) as a criterion for project evaluation in low-income countries. One serious defect in the original formulation[3] of this criterion was that it ignored the problem of varying rates of capital replacement among projects,[4] but its more recent advocates recognise this fault and have altered the formulation into one of maximizing the net rate of turnover.[5]

A major criticism of the rate of turnover criterion derives from Professor A.E. Kahn.[6] The criterion implies that only capital is a scarce resource; and since it ignores payments to other factors, they are taken to have zero opportunity cost.[7] Kahn demonstrated that an

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1. N.S. Buchanan, International Investment and Domestic Welfare; New York; (1945.)
2. J.J. Polak, "Balance of Payments Problems of Countries Reconstructing With the Help of Foreign Loans"; Quarterly Journal of Economics; Vol. 57; (February 1943); pp. 208-240.
3. See N.S. Buchanan, ibid., p. 24.
4. United Nations (ECAFE), "Criteria for Allocating Resources among Various Fields of Development in Underdeveloped Countries"; Economic Bulletin for Asia and the Far East; (June 1961); p.31.
5. See S.Enke, op.cit., p.291.
6. A.E. Kahn, "Investment Criteria in Development Programmes"; Quarterly Journal of Economics; Vol.65; (February 1951); pp.38-61.
7. Whether it is appropriate to attribute a zero opportunity cost to labour in low-income countries where widespread underemployment appears to prevail remains a controversial question. See, for example, J.W. Mellor, op.cit., p. 157. "Contrary to the assumption of much development theory, there is considerable evidence that increased labour input within the traditional framework of production can increase output significantly in most low-income countries and that technological advance requires a complementary input of labour."

evaluation of the contribution of a project to social welfare, requires that factors of production must be valued at their opportunity costs, prices must be corrected for market imperfections, and the external economies deriving from a project must also be included in the valuation of its output.[1]

In addition to these criticisms, we may note from the perspective of the framework developed in Chapter II of this study, that output, which represents the maximand in the capital-turnover criterion, represents an inadequate proxy for the multiplicity of objectives comprising the social welfare function. The maximization of output provides no indication of how output is to be distributed between consumption and investment, and consequently ignores the question of the distribution of consumption over time.[2] Secondly, the maximization of output does not guarantee that the distribution of consumption among the various groups and regions of the society will have improved.[3] Thirdly, the maximization of output indicates nothing regarding the composition of output, so that the question of satisfying 'merit-wants' is ignored.[4] We also note that the capital-turnover criterion does not distinguish between exports and output for the domestic economy, nor between imported

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1. A.E. Kahn, op.cit. See also H.B. Chenery, op.cit. Nevertheless, Kahn finds the rate of turnover "particularly desirable" when there is large scale unemployment, op.cit., p.51; and Chenery finds it "particularly useful for choosing among projects in a given sector," op.cit., p.87.
2. However, under conditions of perfect competition, the market mechanism resolves this problem, and instantaneous Pareto optimality becomes a necessary condition for intertemporal dynamic efficiency. See F.M.Bator, op.cit., p.105.
3. See previous discussion on redistributive objectives.
4. See R.A. Musgrave, op.cit., p.9 and pp.13-14.

and domestic capital, and therefore, provides no indication of the influence of the project on the status of the independence-from-foreign-aid objective.[1] Finally, we note that the capital-turnover criterion ignores consideration of varying effects of uncertainty on output.

1. However, J.J. Polak, op.cit., does argue for separate analysis of balance-of-payments effects in order that exchange rate equilibrium be maintained.

B. Specific Criteria Forms for Economic Development (cont.)

2. The "Social Marginal Productivity" Criterion

The social marginal productivity criterion (SMP) was formulated by Professor Kahn,[1] partly in reaction to certain inadequacies of the rate-of-turnover criterion, and was further developed by Professor Chenery.[2] Professor Chenery defines SMP as the "...average annual increment in national income (plus balance-of-payment equivalent) from the marginal unit of investment in a given productive use."[3]

Thus the variables in the objective function to be maximized are the national income and the balance-of-payment effect (or equivalently, the independence-from-foreign-aid objective), and the active constraint is the quantity of invested capital. To formulate the criterion, Chenery begins with "the net private return over costs per unit of investment", and then corrects for (a) tariffs, taxes, and subsidies, (b) external economies, and (c) unused resources,[4] in order to "arrive at the net

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1. A.E. Kahn, op.cit., pp.38-61.
2. H.B. Chenery, op.cit., pp.76-96.
3. ibid., p.83.
4. "The cost to society of employing unemployed labour, for example, is only the increase in consumption which results." ibid., p.82. The intention undoubtedly is to emphasise that resources be valued at opportunity costs, but this particular formulation is clearly unacceptable. Are not unemployed labourers members of society? When the objective function is national income, an increase in consumption would tend to reduce the resources available for investment, but would certainly not reduce national income. Compare A.K.Sen, "Some Notes on the Choice of Capital Intensity in Development Planning"; Quarterly Journal of Economics; Vol. 71; (November 1957); pp. 561-584; p.563, f.n. 8.

social return".[1] In addition, a premium is attached to foreign exchange earnings or savings. The basic formulation of the SMP criterion takes the form of the following ratio,[2]

$$SMP = \frac{(V - C) + rB}{K}$$

where,

V = annual social value added domestically, which is comprised of the market value of output (corrected for subsidies and protection), plus addition to value from external economies, minus the cost of imported materials;

C = total annual cost of domestic factors (including replacement costs);

B = total annual balance of payments effect;

K = increment to capital (investment); and

r = premium on improvements in the balance of payments.

Chenery has classified the balance-of-payments effects of a project in the following manner;[3]

Investment Effects

(1) Purchase of machinery and equipment abroad.

(2) Multiplier effects of investment on income and imports.

Direct Operating Effects

(3) Output of a commodity which increases exports or is a substitute for imports.

(4) Imports (direct and indirect) for production of the given commodity.

(5) Reduction of import requirements for production of commodities for which output is a substitute.

Indirect Operating Effects

(6) Multiplier effect of inflationary financing of consumption.

(7) Multiplier effect of change in export (import) surplus.

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1. H.B. Chenery, op.cit., p.82.
2. ibid., p.83.
3. ibid., p.88.

Thus, the SMP [1] criterion corrects many of the defects of the rate of turnover criterion. One important correction which Chenery appears to neglect, however, is to value public investment capital at its opportunity costs. Replacement costs enter into the total cost (C) term in the criterion, where variations in its valuation could affect project selection.[2] In addition, the use of the same discount rate for balance-of-payments effects and future increments of national income,[3] seems to be an unjustified simplification.

Criticisms of the SMP criterion have been directed both at the form of its maximand[4] (numerator) and its limiting constraint (denominator).[5] With respect to the maximand, we may first note that Chenery's clarification of balance-of-payments effects of a project is a useful contribution.[6] His acknowledgement of redistributive objectives in the social welfare function is also important.[7] However, he does not include redistributive objectives in the final formulation of the criterion because of the apparent difficulty associated with their measurement.[8]

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1. Professor Eckstein notes that it is technically incorrect to view SMP ratings as 'marginal', and that the criterion would more appropriately be named "social average product', since it is the average product of a project that is computed; "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics"; op.cit.,p.59, f.n. 8.
2. Compare ibid., p. 64.
3. H.B.Chenery, op.cit., p.94.
4. See, for example, W. Galenson and H. Leibenstein, op.cit.,pp. 343-370; and A.K. Sen, "Some Notes on the Choice of Capital Intensity in Development Planning"; op.cit., pp.562-564.
5. See, for example, S.Enke, op.cit., pp.292-295; R.S. Eckaus, "Technological Change in Less Developed Areas"; in Development for the Emerging Countries. An Agenda for Research. The Brookings Institute; Washington, D.C., (1962); Reprinted in G.M. Meier, op.cit., p.244 and F.M. Bator, op.cit., p.100.
6. Compare O. Eckstein, "A Survey of the Theory of Public Expenditure Criteria", op.cit., p.489.
7. H.B. Chenery, op.cit., p.80.
8. ibid.

Such difficulties will depend upon how redistributive objectives are defined. In principle, it seems that they can be entered explicitly in an operational objective function, and they, therefore, should be. Thus, for example, a premium could be assigned to income accruing to a particular region, or to particular groups within the population.[1]

However, the principal inadequacy of the objective function in the SMP criterion is the dominant role it assigns to increments in national income. As has already been pointed out with respect to the rate-of-turnover criterion, this approach ignores explicit consideration of the growth path of national income, and also, what is more relevant, that of consumption.

The criticism of investment costs (k) performing the function of the limiting constraint in the criterion, is based upon the fact that while public investment may be subject to a budget constraint, the Government's objectives in resource allocation must be directed beyond the value added of public projects, and must, therefore, give appropriate weight to other resource limitations.

> "...a logical investment criterion...should be based on the resource limitations of the economy, and not on some government agency, although this point is often overlooked. There is usually no obvious warrant for assuming that capital is scarce and labour is free."[2]

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1. See, for example, S.A. Marglin, Public Investment Criteria; op.cit., p.23.
2. S. Enke, op.cit., p.295. See also R.S. Eckaus, op.cit., for a similar position.

B. Specific Criteria Forms for Economic Development (cont.)

3. The Social Investment Rating (SIR)

The Social Investment Rating, is the name that Professor Enke [1] gives to his modification of the SMP criterion, and is essentially of the same form as the criterion proposed by Professor Ahumada.[2] Professor Enke's formulation is the following:

$$SIR = \frac{R - M}{L + K_a}$$

Where, R = market value of annual output (presumably corrected for taxes, tariffs, and subsidies) plus ascertainable net external economies.

M = cost of materials purchased from other firms;

K_a = annual capital expense; and

L = annual labour cost.

Thus the SIR criterion is the ratio of annual value added to annual factor costs. The alteration that has been effected in the maximand, from value net of opportunity cost (of the SMP) to value added (in the SIR), is merely a formal matter not affecting SIR rankings.[3] The defects attributed to the SMP criterion regarding its concentration on maximizing national income, and its omission of the valuation of capital at its social opportunity cost are equally present in the SIR criterion.

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1. S. Enke, op.cit., pp.294-5.
2. J. Ahumada, Investment Priorities; document submitted to the round-table conference of the International Economic Association, Rio de Janeiro, (August 19-28, 1957); summarised in United Nations, Manual on Economic Development Projects;New York; (1958); pp.237-8.
3. The maximand of the SMP criterion differs from that of the SIR by annual labour and capital costs. Thus $V-C = R-M-(L+K_a)$. if this alteration is made in the numerator of the SIR,

$$\frac{R-M-(L+K_a)}{L+K_a} = SIR - 1,$$ which will not alter the relative ranking of projects.

Although Enke is not explicit about the valuation of labour at opportunity costs and corrections for balance-of-payments effects, the cursory manner in which the SIR criterion is presented does not justify these detailed criticisms of the SIR, especially since Enke does not present an unfavourable treatment of these aspects in his discussion of the SMP criterion. The critical adaptation provided by the SIR criterion appears in the denominator: it is here that Enke[1] and other critics[2] of the SMP criterion, point to its inadequacy. The SMP formulation presents government resource allocation as a'suboptimization' problem of maximizing the output deriving from the government's investment budget, rather than the broader optimization problem of resource allocation for the economy as a whole.[3]

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1. S.Enke, op.cit.
2. R.S. Eckaus, op.cit., and J. Ahumada, op.cit.
3. If however, public investment capital was valued at its social opportunity cost and there were no budget limitations on public investment, there would be no discrepancy between these two maximization problems. See S.A. Marglin, "The Opportunity Cost of Public Investments"; op.cit.

B. Specific Criteria Forms for Economic Development (cont.)

4. The Marginal Reinvestment Criterion

Professors Galenson and Leibenstein [1] have proposed that the goal of economic development policy should be the maximization of per capita output "at some time in the future",[2] which led them to recommend the "marginal per capita reinvestment quotient" as a criterion for project evaluation.

> "To secure a clear notion of what is meant by the marginal per capita reinvestment quotient we must consider the basic factors involved in its determination. Briefly stated, the seven basic factors are as follows: (1) gross productivity per worker; (2) 'wage' goods consumed per worker; (3) replacement and repair of capital; (4) increments in output as a result of noncapital-using innovations, such as improvements in skills, health, energy, discipline, and malleability of the labour force; (5) declines in mortality; (6) declines in fertility; and (7) direction of reinvestment." [3]

Abstracting from the authors' description of the effects of project selection on the population growth rate, the maximization of output at a future date requires the maximization of capital formation at that date, given the existence of surplus labour. Thus the criterion for project selection is to maximize the net flow of investment that follows from each unit of present investment.

The authors further assume that wage-earners will consume their entire income while profit-earners reinvest their entire income, so that from the perspective of growth maximization, wages are a cost,

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1. W. Galenson and H. Leibenstein, "Investment Criteria, Productivity, and Economic Development"; op.cit.
2. ibid., p.345
3. ibid., p.352

and the objective reduces essentially to the maximization of profits per unit of investment. In their basic model, Galenson and Leibenstein express the reinvestment coefficient as follows:[1]

$$\frac{p - ew}{c} \quad [2]$$

where,

p = output per machine;

e = number of workers per machine;

w = real wage rate; and,

c = cost per machine.

We note that this criterion is of the same general form as the (reciprocal of the) recoupment period criterion, and will, therefore, be biased toward projects having long lives, a property which the authors describe as conducive to growth.[3]

We may further note, following Professor Sen,[4] that the criterion may be transformed into the growth formula associated with Professors Harrod and Domar.

$$\frac{p - ew}{c} = \left(\frac{p}{c}\right) : \left(1 - \frac{ew}{p}\right) = \frac{s}{a} \quad ,$$

where,

a = capital coefficient = $\frac{c}{p}$,

s = savings ratio = $\frac{p - ew}{p}$,

when all wages are consumed, and the remaining factor incomes are reinvested.

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1. W. Galenson and H. Leibenstein, op.cit., p.357.
2. A similar criterion is presented in M.H.Dobb, "Second Thoughts on Capital Intensity", Review of Economic Studies; Vol.24; (1956).
3. W. Galenson and H. Leibenstein, ibid., p.362.
4. A.K. Sen, "Some Notes on the Choice of Capital-Intensity in Development Planning"; op.cit., p.565

Thus maximization of the reinvestment coefficient leads to the maximization of the rate of growth. After reviewing social and demographic considerations associated with investment, Professors Galenson and Leibenstein recommend capital-intensive investment, and the maximization of the capital-to-labour ratio.[1]

The Galenson-Leibenstein criteria have been widely criticised.[2] For purposes of the present study, we note first that their analysis does not entail explicit corrections for market imperfections,[3] nor suggestions for the calculation of the social opportunity cost of public investment capital. In addition, the conventional types of 'dynamic' external economies[4] do not enter their analysis. Furthermore, within the context of the authors' growth-maximizing objective, by assuming the investment total in the initial period fixed, in their rigid assumption about savings propensities out of profits and wages, they ignore the effects of project selection upon the quantity of investment. As Professor Sen[5] has pointed out, different propensities to consume among the factors of production

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1. W. Galenson and H. Leibenstein, op.cit., pp.356 and 370.

2. See, for example, O. Eckstein, "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics"; op.cit., pp.65-66; F.M. Bator, op.cit., pp.104-5; A.K. Sen, "Some Notes on the Choice of Capital-Intensity in Development Planning"; op.cit.,pp.564-567; J. Moes, "Investment Criteria, Productivity and Economic Development: Comment"; Quarterly Journal of Economics; Vol.71; (1957); pp.161-164; and H.B. Villard, "Investment Criteria, Productivity and Economic Development: Comment"; Quarterly Journal of Economics; Vol.71; (1957) pp.470-475.

3. With respect to labour, they make the remarkable prescription that governments of low-income countries "alter conditions to conform with our criterion by making labour scarce artificially", (op.cit.,p.368). So that private capital will also be directed to capital-intensive investment.

4. See earlier discussion of this topic. Galenson and Leibenstein do, however, extensively discuss the effects of investments on the quality of the labour force (ibid, p.355) and the effects of urbanization on the population growth rate. (ibid, pp.363-7)

5. A.K. Sen, ibid, p.566.

contributing to alternate investments, will result in different quantities of investible surplus. This effect may be substantial where alternate investments emphasize the employment of unskilled labour and skilled labour respectively, where skilled labour may be expected to have higher marginal propensities to consume, for example.

Professor Bator[1] has demonstrated the logical frailty of the prescription of maximizing capital-to-labour ratios so that wage bills will be relatively small, and therefore, savings and reinvestment may be large. More capital-intensive investment resulting in higher labour productivity may require that higher wages be paid where, for example, unions are powerful, and the resultant ratio of profits to wages need not be higher; and, where the choice of capital-intensive techniques precludes the maximization of output, the absolute value of profits and hence reinvestment may be smaller than would otherwise be possible.[2]

However, the principal criticism of the Galenson-Leibenstein criteria must be directed at their choice of an objective function to represent social welfare. The maximization of the rate of growth contradicts our entire discussion of social time preference for present consumption; governments must be concerned with the welfare of the present generation as well as with that of (the presumably wealthier) generation of the future.[3] Furthermore, the authors ignore the social objective of

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1. op.cit., p.104

2. Compare with O.Eckstein, "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics"; op.cit., p.66.

3. Compare J. Moes, op.cit., p.163; and A.K. Sen, "Some Notes on the Choice of Capital-Intensity in Development Planning"; op.cit., p.567: "While the social marginal productivity criterion pins its attention on the present, the rate-of-reinvestment criterion goes to the other extreme."

independence from foreign aid; with the present productive structure of most low-income countries, capital-intensive investments will tend to have a higher import content.[1] Finally, with respect to redistributive objectives, minimization of the wage bill must, by most standards, be viewed as a regressive proposition.[2]

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1. Compare with A.K. Sen, "Some Notes on the Choice of Capital-Intensity in Development Planning"; op.cit., p.567.

2. Compare with O.Eckstein, "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics"; op.cit., p.84.

B. Specific Criteria Forms for Economic Development (cont.)

5. The Time Series Criterion

The time series criterion has been proposed by Professor A.K. Sen [1] in response to the polar presumptions regarding social time preferences that are inherent in criteria that maximize current national income (the rate-of-turnover, SMP and SIR) on the one hand, and the marginal reinvestment criterion on the other. Criteria having national income as their maximand ignore its composition and consequently, the reinvestment that will be induced from the original selection of projects; the marginal reinvestment criterion in seeking to maximize growth, ignores the consumption available to the current generation. Professor Sen's reconciliation of these two approaches takes the reinvestment effects of projects into account, but avoids the shortcomings of maximizing reinvestment by taking explicit account of social time preferences for current consumption, and of uncertainty.

Professor Sen proposes his criterion for choosing among alternate techniques of production of a given type of output. His analysis of the potential reinvestment forthcoming from a given process extends beyond the surplus deriving from the operation of the process, to analysis of the surplus that derives from the production of the capital for the process. Thus, if there is a substantial import content to the capital, and the exchange rate is overvalued, the capital diverted to the production of exports to finance the importation, will exceed the capital required

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1. A.K. Sen, "Choice of Technique: An Aspect of the Theory of Planned Economic Development"; op.cit.; and "Some Notes on the Choice of Capital-Intensity in Development Planning"; op.cit.

for an equally priced, domestically produced investment.[1] Furthermore, the propensities to consume of the factors employed in the production of the capital are considered, to compare the effects of alternate investments upon the total investment available in the initial period;[2] so it is not merely the reinvestment coefficient that is relevant, but rather the product of the reinvestment rate and the volume of investment that occurs in the initial period. Professor Sen's analysis also does not entail the simplifying assumptions of Professors Galenson and Leibenstein[3] with respect to the propensity to consume out of wages. The extra consumption induced by one unit of extra employment is given by:[4]

$$w \cdot c - d(1 - c') \quad ,$$

where, w = wage rate per person;

d = consumption per person when unemployed;

c = propensity to consume of the worker; and,

c' = propensity to consume of the worker's former host.

Alternate procedures for valuing labour with (assumed) zero marginal productivity will be described to illustrate the different perspectives inherent in the various criteria. When the objective function is the maximization of current national income, additional employment has a zero opportunity cost, and is thus valued at zero.[5] However, when the objective function is the maximization of surplus, the cost of employing an additional worker includes his own increase in consumption, that of his previous hosts, and various 'urbanization' costs (housing, electricity,

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1. A.K. Sen, "Choice of Technique: An Aspect of the Theory of Planned Economic Development"; op.cit., Chapter VI.
2. A.K. Sen, "Some Notes on the Choice of Capital-Intensity in Development Planning"; op.cit., pp.566 and 568.
3. Galenson and Leibenstein, op.cit.,
4. A.K. Sen, "Choice of Technique:....."; ibid., p.64.
5. See, for example, A.E. Kahn, op.cit.

Sewage, etc.) and the transportation costs required to bring him into employment.[1] The time series criterion reconciles both of these effects.[2]

Professor Sen's criterion compares the time series of consumption flows resulting from alternate investments, and from the reinvestment that they induce. Whereas a more capital-intensive technique may induce greater reinvestment (because of varying savings propensities of owners of different types of factors), an equal investment in a labour-intensive technique may result in greater immediate production of consumption goods. The problem is to choose the production process which will balance these two effects.[3] Professor Sen's solution to the problem requires the choice of a time horizon by policy-makers, which should be principally directed by considerations of social time preference for present consumption and uncertainty.[4] The figure[5] illustrates time series of consumption, H'H and L'L, for two techniques requiring equal initial investment costs. OT is the "period of recovery",[6] or the time

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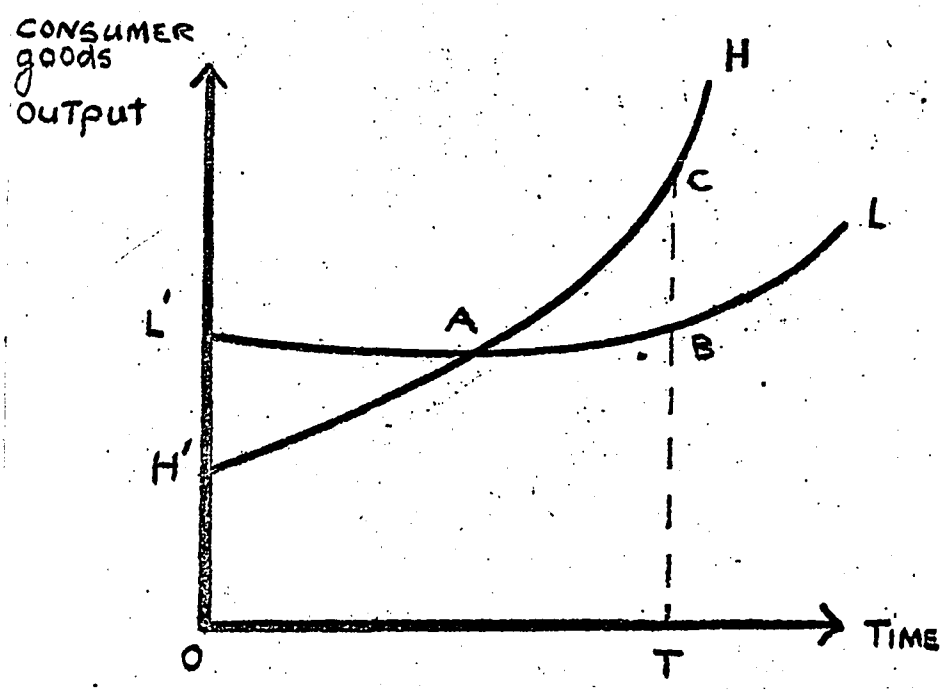
1. See, for example, W.Galenson and H.Leibenstein, op.cit., and M.H. Dobb, op.cit.
2. A.K. Sen, Choice of Technique: .....; op.cit., p.63.
3. Where a technique is superior with respect to both effects, then there is clearly no problem. Compare Galenson and Leibenstein, op.cit., p.348, Figure I.
4. A.K. Sen, op.cit., Chapter VIII.
5. Compare ibid., p.32.
6. Professor Sen notes the similarity of this concept to the Soviet 'period of recoupment'. He points out, however, that while the period of recoupment compares fixed-capital and operating costs to produce a given output; his own criterion is concerned with alternate consumption streams resulting from a given quantity of investment, which he considers a more appropriate approach for low-income countries. See, ibid., p.33, f.n.23.

Figure 11



required for aggregate consumption from the capital-intensive investment (H) to equal that from the labour-intensive investment (L). (i.e., area L'H'A = ABC). The period of recovery is then compared to the time horizon: if OT is less than the time horizon, technique H is to be chosen; if it is greater, technique L is to be chosen.

We first note the arbitrariness associated with the period of recovery approach, as with the recoupment period approach: equal value is placed on all consumption occurring within the time horizon, while zero value is given to consumption forthcoming thereafter.[1] However, the choice of a social rate of discount must in practical application also involve a certain amount of arbitrariness.[2] Basically, Professor Sen's study

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1. Compare O. Eckstein, "A Survey of the Theory of Public Expenditure Criteria"; op.cit., p.494. Professor Sen recognizes the need to specify either terminal capital requirements or a terminal rate of growth; op.cit., p.79.

2. See, for example, A.C. Harberger, op.cit.

deals effectively with the various considerations which are relevant to the aggregate consumption objective of social welfare.[1] However, that is what comprises its limitation; the study does not take into explicit account the multiplicity of objectives of economic development: redistributive objectives, the satisfaction of 'merit wants', and the objective of achieving independence from foreign aid have not been integrated into Professor Sen's analytic structure.

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1. External economies are discussed in "Choice of Technique: ....."; op.cit., p.59.

C. The Interdependence Problem

From a general equilibrium perspective of the economic process, every economic activity necessarily has repercussions upon every other, and the effects of introducing a new activity can only be determined by the solution of a set of simultaneous equations for the entire system.[1] This consideration has led to the formulation of the "with and without" principle to provide a correct theoretical basis for project evaluation.[2]

> "In evaluating the benefits and costs of a project, two situations must be compared: the development of the economy with the project and the development that would occur without it. The change in the path of the economic system because of the project involves certain costs and certain benefits, and it must be the objective of benefit-cost analysis to identify these changes." [3]

A partial-equilibrium analysis will be consistent with this principle for marginal adjustments in the competitive model,[4] and may, therefore, provide a useful, practical procedure in an economic context similar to that of the United States.[5]

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1. R.E. Kuenne, op.cit., Chapter 1.
2. See M.M. Regan and E.G. Weitzell, "Economic Evaluation of Soil and Water Conservation Measures and Programs"; Journal of Farm Economics; (November 1947); pp.1275-1294; J. Tinbergen, op.cit., p.33; and O.Eckstein, Water Resource Development; op.cit., pp.37-38 and 51-52.
3. O.Eckstein, ibid., p.51.
4. See, for example, A. Maas, and others, op.cit., p.23.
5. See, for example, J.V. Krutilla, op.cit., p.24; and A.R. Prest and R. Turvey, op.cit., p.162.

In the context of Development Planning, however, neither marginal adjustments, competitive conditions, nor the desirability of the achievement of Pareto optimality which would follow from a competitive situation, can justifiably be assumed, as has been elaborated in Chapter II. That this has been recognized by many of the authors of proposed criteria for the evaluation of development projects, may be readily seen from their explicit inclusion of net external economies among the benefits deriving from projects.[1] In the practical application of these criteria, however, requirements of uniformity in evaluation procedures,[2] as well as the need for safeguards against unprincipled inflation of external economies by interests which directly benefit from the execution of a project,[3] has resulted in substantial circumscription of the types of relevant effects that are counted. In general, these are limited to effects on activities in 'vertical' propinquity to the project: 'forward' and 'backward' effects,[4] which consist of increments in benefits and costs that accrue to activities which directly employ the output of the project, and those which supply its inputs, respectively. Although such calculations are an improved basis for project evaluation over evaluations based on a pure partial-equilibrium

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1. See, for example, H.B. Chenery, op.cit; idem, "The Interdependence of Investment Decisions"; in M. Abramovitz et al., The Allocation of Economic Resources; Stanford; (1959); pp.82-120; A.E. Kahn, op.cit; and S.Enke, op.cit., pp.294-5.
2. United Nations, Manual on Economic Development Projects; op.cit.,p.220.
3. See, for example, S. Enke, ibid, pp.295-297.
4. See United Nations, Manual on Economic Development Projects; op.cit., pp.220-222. Also, compare A.O. Hirschman on backward and forward linkages, "The Strategy of Economic Development"; Yale University Press; New Haven; (1958);pp.100-117.

analysis, and may frequently result in an adequate 'first approximation',[1] there still remains much to be desired. The evaluation of forward and backward effects constitutes the definition of an arbitrary sub-system in which to view the effects of a project, while a theoretically adequate solution requires comparisons of the entire economic system "with and without" the project in question.

A second aspect of project interdependence, the 'incompatibility' situation, can generally be adequately incorporated by the reformulation of criteria into their incremental forms.[2] Furthermore, there is an adequate procedure for dealing with situations when interdependence among projects may be recognised as being of a direct nature.

> "Where the costs and/or benefits of two schemes A and B are interdependent in the sense that the execution of one affects the costs or benefits of the other, they must be treated as constituting three mutually exclusive schemes, namely A and B together, A alone and B alone." [3]

The unfortunate fact, however, is that all projects are ultimately interdependent in this sense.

With the present state of development of analytical techniques, the complete set of repercussions of a project on the economic system can not be adequately evaluated.[4] Not only will the execution of a project whose effects are of a non-marginal nature affect the evaluation of its own costs and benefits, but also of those projects whose inputs and outputs

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1. See H.B. Chenery, "The Interdependence of Investment Decisions"; op.cit., pp.110-111; and A.K. Sen, "Choice of Capital-Intensity Further Considered"; Quarterly Journal of Economics; Vol.73; (1959); pp.466-484; p.481.
2. See foregoing discussion of general criteria forms; and M.S. Feldstein and J.S. Flemming, op.cit.,pp.80 and 83.
3. A.R. Prest and R. Turvey, op.cit., p.176.
4. See, for example, A.K. Sen, 'Choice of Techniques; An Aspect of the Theory of Planned Economic Development; op.cit., Appendix E.

are either substitutes or complements to those of the project in question. In the broad sense in which the objectives of Development Planning were defined in this study, all projects will be interdependent with respect to each objective, in the final analysis: every project contributes to aggregate consumption, has some effects on distribution, the balance-of-payments, and on the composition of merit-wants.

As an illustrative example, consider the effect of project interdependence on the independence-from-foreign-aid objective. The choice of a discount rate to allow the evaluation of a project's effects on the balance of payments in a future period, will depend on the state of the balance of payments in that period "without" the project; but the particular state that exists at that time will depend on the particular group of projects that is currently executed, private as well as public. A similar problem arises in connection with criteria for eliminating projects from consideration for immediate execution: as the volume of investment increases at a given point in time, project interdependence tends to cause a positive displacement of the entire ranking function, so that projects that would be 'eliminated' at a small volume of investment, may not be when it increases.[1] A solution which is correct would require comparisons of the net present benefits of all possible combinations of potential projects, and such a procedure is not possible in practice.[2]

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1. See O.Eckstein, "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics"; op.cit.,pp.63-64.

2. See R.N. McKean, op.cit., p.88.

Thus to place project evaluation criteria into proper perspective: they perform an important practical function in Development Planning, but it must be emphasized that they only provide a first approximation - and may result in incorrect decisions, no matter how carefully they are formulated. It should also be emphasized that the probability of error will be reduced as the range of application of these criteria is successively narrowed down to the comparison of projects that are 'similar'; i.e., to projects having similar outputs and inputs, similar lengths of life, and similar degrees of uncertainty associated with their outcome.[1]

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1. Compare O.Eckstein, Water Resource Development; op.cit., p.55

CHAPTER IV

Summary and Conclusions

Most of the low-income countries are currently employing Development Planning as the instrument for achieving economic development. Economic development consists in the attainment of a multiplicity of objectives which in this study have been broadly categorized as: increasing aggregate consumption, redistributive objectives, the satisfaction of merit-wants, and independence from foreign aid. Given these objectives of the social welfare function, Development Planning may be described as the maximization of social welfare, and project evaluation is that aspect of Development Planning devoted to the selection of the optimal set of projects.

A framework for social welfare maximization in the context of economic development, was suggested in Chapter II. This consisted of a general presentation of the planning problem, followed by a review of three aspects of social welfare maximization. First, indivisibilities and the type of market imperfections which tend to be found, were presented as impediments to the achievement of conditions of perfect competition. Secondly, given perfect competition, the existence of public goods and non-market interdependence would prevent the attainment of a Pareto optimum. Thirdly, Pareto optimality may not be consistent with the objectives of Development Planning, as exemplified by the operation of dynamic external economies and the infant industry argument. An approach to the intertemporal comparison of social costs and benefits and the problems resulting from uncertainty, were also discussed.

In Chapter III, various operational criteria for partial-equilibrium analysis of projects were surveyed. General criteria forms for the elimination from consideration of uneconomic projects, for the relative ranking of projects, and for the scheduling of the initiation of projects, were described and their respective limitations were examined. The general forms were then compared to determine their specific biases and the circumstances under which they provide compatible rankings of projects. In the second part of the chapter, criteria which have been specifically formulated for project evaluation in the context of economic development were described, and their social welfare implications were examined. Finally, the problems that result from interdependence among projects were discussed, in order to emphasize the limitations that are generally inherent in all partial-equilibrium approaches to project evaluation.

The following conclusions have emerged from the study. All partial-equilibrium approaches must necessarily yield only a 'first approximation' to an optimum investment program because of the pervasive nature of project interdependence; social welfare maximization requires the comparison of all the attainable combinations of projects to determine the combination that yields maximum benefits. Secondly, the selection of a 'general' criterion form has significant social welfare implications which do not receive sufficient recognition in their application. Thirdly, the partial-equilibrium criteria that have been proposed for project evaluation in the context of economic development have been found, generally to be lacking in the explicit recognition of the multiplicity of objectives

that comprise economic development, as well as in some of their technical aspects. Fourthly, under existing limitations of data, personnel and analytical techniques, partial-equilibrium analysis of projects remains, nevertheless, a necessary aspect of Development Planning. These criteria, however, cannot be expected to substitute for strategic decisions of Development Planning regarding the distribution of consumption over time, the distribution of consumption among members of society at all points in time, and the composition of consumption over time, although these decisions must be reflected in project evaluation criteria. The scope of partial-equilibrium criteria should be limited to the comparison of 'similar' projects: projects should have similar inputs and outputs, similar durabilities, and comparable degrees of uncertainty associated with their outcome. We conclude by emphasizing the urgent need for the development of analytical techniques which will provide operational alternatives to the approach of partial-equilibrium criteria.

CHAPTER V

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