AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch [illegible]

1. SUBJECT CLASSIFICATION
A. PRIMARY
TEMPORARY
B. SECONDARY

2. TITLE AND SUBTITLE
A critical survey of project planning

3. AUTHOR(S)
Tryon,J.L.; Cookson,F.E.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1966	204p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
NPA

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(In Working paper M-8625)

9. ABSTRACT
(DEVELOPMENT R&D)
(ECONOMICS R&D)

10. CONTROL NUMBER
PN-[illegible]

11. PRICE OF DOCUMENT

12. DESCRIPTORS

13. PROJECT NUMBER

14. CONTRACT NUMBER
Repas-9 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-73)

NPA M-DE-335

CENTER FOR DEVELOPMENT PLANNING
NATIONAL PLANNING ASSOCIATION
1525 Eighteenth Street, N. W.
Washington, D. C. - 20036

A CRITICAL SURVEY OF PROJECT PLANNING

by

Joseph L. Tryon and Forrest E. Cookson

~~(Working paper; not to be quoted)~~

M-8625
March, 1966
(Revision of M-8406)

CORRIGENDA

Page	Error	Correction
14 & 197	Dirlam	Dirlan (correct spelling)
19	Lewis, A. W.	Lewis, W. A. (reverse initials)
22	Rodin	Rodan (change i to a)
48	Eckstein, 1952	Drop 1952
50	Arndt, Vol. XXI	Vol. XXXI (add X)
50	Reiter, G.	Reiter, S. (change initial)
50	Malgren	Malmgren (insert m)
118	Merrett and Sykes, 1963	Merrett, A. J., and Sykes, A., The Finance and Analysis of Capital Projects, New York: John Wiley, 1963. (Should be written in full.)
120	Dryden, Myles	Miles (change y to i)
122	Merrett	Merrett and Sykes, 1963. (add t to Merret)
143	Sriniysan	Sriniyasan (insert a)
158	Marglin, 1961	Marglin, Approaches ..., 1963. (Add underscored word and dots; change 1 to 3.)
161 & 175	Hershleifer	Hirshleifer (change e to i)
176	Wiley, 1958	1959 (change 8 to 9)
175		; Hirshleifer, J., "Investment Decision under Uncertainty: Choice-Theoretic Approaches," Quarterly Journal of Economics, Vol. LXXIX, No. 4 (November, 1965), pp. 509-36. (Add new reference to footnote 2.)

I. INTRODUCTION

This paper is a critical survey of the literature in English on the subject of project analysis and selection. The general aim is to lay out the significant problems of project planning, from the point of view of a planner in a developing country, and to present what is currently known on the subject. While much of the discussion is theoretical, the basic orientation is operational. Theory is discussed in terms related to practice in planning offices of the world's less developed countries. Clearly a fuller understanding of the theory underlying a particular operational prescription will enable planners better to judge the prescription's utility in their own environment. In this sense, the paper is a guided tour through the hazards of project planning.

The survey is selective, largely because so much has been written that is relevant to the subject. We hope, however, that the major contributions to the subject have been recognized and presented accurately.

At some points we have attempted to fill in gaps in the theoretical literature. To do so has required reference to previously unpublished work. The inclusion of discussions of this unpublished work raised the problem of its accessibility. Rather than burdening the text with extensive theoretical arguments, it was decided that the complete theoretical treatments of matters not available elsewhere should be incorporated in a separate document which could be obtained by interested readers. At the points where discussions of these new theoretical results are included, suitable references are made to a separate document which can be obtained from the Center for Development Planning.

The material is presented in five major parts. The first is devoted to an idealized three-step scheme of project planning. The three steps are: (1) identification of possible projects, (2) evaluation of their costs and benefits, and (3) selection of projects to be executed. This three-step scheme is simply a framework for the subsequent discussion of the project planning process. The three succeeding parts are devoted to an elaboration of problems of project planning within this framework. The part on project perception deals with the problem of the shortage which exists in most less developed countries of suitable development projects. The part on evaluating benefits and costs deals with ways to translate the physical consequences of projects into usable value terms. The part on selecting projects deals with criteria to select projects for execution.

The final part is devoted to consideration of the institutional setting of project planning. This part presents a comparison between an ideal project planning system which seems to be evolving in planning literature, and the present planning systems which exist in the less developed countries.

II. AN IDEALIZED SCHEME OF PROJECT PLANNING

In this section an idealized scheme of project planning will be outlined. It is presented only as a convenient framework for subsequent discussion. A different scheme could well have been chosen, for the breakdown of the process of project planning which it represents is, to a large extent, arbitrary. Most of the points which we wished to make could have been fitted into other schemes, but the one used here seemed best to focus on certain aspects of project planning which we feel require emphasis.

1. The Nature of a Project

Before presenting the idealized scheme, it will be helpful to consider just what a project is. A project is defined as the use of one or more scarce resources during a specific time period for the purpose of producing some economic return or output at a later time. In a very general sense, a project can be conceived of as an allocation of capital, and the allocation of capital simply means committing resources in the present in order to gain output at some later time. The time element in this definition is central. However, the concept of investment requires further elucidation. Our approach here is to take a very general view of the capital formation or investment process. Included in the concept of investment are the use of resources for education, health, research and development, agricultural extension, and other types of public sector expenditure which usually are not conventionally considered to be investment. We specifically want to avoid a narrow definition of investment which covers only plant and equipment expenditures.

2. Classes of Projects

The definition of a project offered here is so general that some examples are needed to illustrate its breadth. It will also be helpful to distinguish among types of projects. First, a very simple example: the investment consists of the construction of a shoe factory. After completion of construction, the shoe factory produces shoes which represent the economic benefit. The kind of investment contained in this example characterizes a large class

of development projects. Such projects have tangible investment requiring capital goods and taking the form of specific physical construction. They provide a future flow of services or goods. We will designate them as class one projects. The bulk of class one projects would be the plant and equipment expenditures of productive enterprises.

A second class of projects may be illustrated by expenditures to pay salaries of teachers who are working to instruct the population in new skills. As a result of such instruction, the workers increase their capacity to produce and, consequently, it is clear that the investment--teachers' salaries--results in a future increase in output. This example illustrates a class of projects which operates to expand the supply of factors of production other than physical capital, and are designated as class two projects. Education works to expand the supply of trained persons. Health projects help to expand the supply of labor of all types, for example, by reducing absenteeism and increasing labor productivity. (There are, of course, many other effects of health projects which are equally important.)

Projects which expand the supply of knowledge make up the third class. Geological surveys and agricultural research are examples. Projects to transfer technical knowledge from abroad would also fall in this class. If we were to treat knowledge as a factor of production, research and development could be put in the second category. However, it turns out to be useful to treat research and development expenditures, or any expenditures which increase the supply of knowledge, as a separate class of projects.

The fourth and final class is institutional reform. Land reform is a common example of this type of project. Others are the establishment of capital markets and of producers' cooperatives. These projects may have a direct or indirect effect on future output. Land reform may have a direct effect by providing incentives to farmers to produce more. Establishing a capital market may have an indirect effect by leading to increased saving and investment, which, in turn, results in increased future output.

This fourth class is a major contributor to development as opposed to growth. Development in this sense implies significant structural changes in an economy, as well as simple additions to output. Since structural change is an important characteristic of economic development, projects which contribute to such changes must not be neglected.[1/]

The four classes of projects noted above are aimed, respectively, at increasing physical plant and equipment, increasing non-capital factor supplies, widening the knowledge of possible productive techniques and opportunities, and inducing institutional changes which will lead society to utilize its resources more effectively. These four classes cover the possible sources of economic growth and development of an economy. It should be noted that it is possible for a given project to contain aspects of two, three, or even all four classes; projects need not necessarily fall in only one class.

1/ For a discussion of the need to view development as a process of structural change, see Paauw, D. S., "A Framework for Development Planning Research: A Typology Approach," Center for Development Planning, Field Research Framework, Memorandum No. 2, July 7, 1965, M-8409, 36 pages.

3. Summary of the Idealized Project Planning Scheme

Let us now proceed to an examination of the idealized project planning scheme. The project planner has the following basic problem. He has under his control certain resources. The time pattern of welfare of a society depends, in part, on the sacrifice in the present of the resources which the planner controls and the resulting gain in the future supply of the goods and services which the executed projects will produce. It is his responsibility to choose those projects which will contribute most to the welfare of society. The process by which the project planner will pursue this goal consists of three steps. These three steps in the idealized scheme are (1) gaining knowledge of the physical characteristics of projects which are technically possible to execute, (2) translating the physical results of possible projects into social benefits and sacrifices, and (3) selecting projects for execution.[1/] The remainder of this paper is organized on the basis of these three steps. The nature and significance of the steps will be examined briefly, and then the literature survey will be presented within the three-step framework.

The first step is what might be called extending the perception of the project universe. The project universe in this sense is the collection of all projects which could actually be executed on the basis of available

---

1/ For a similar breakdown, see Tinbergen, J., "Project Criteria," in Zimmerman, L. J., (ed.) Economic Planning, Publications of the Institute of Social Studies, The Hague, 1963, p. 9.

resources and current technology. It is the universe of projects in physical terms with no value placed on the inputs or outputs of individual projects. Perception of any given project is taken to be total; i.e., all of the physical consequences of a project are known when it is perceived, whether they are directly associated with the project or are external to it.

The second step is translating the physical outcomes of projects into social welfare terms. The problem is that the resources used up and the outputs of projects are very diverse. Some means must be established for making the diverse inputs and outputs of projects commensurable. The inputs and outputs of projects are diverse both with respect to their physical characteristics and with respect to the timing of the use of inputs and the availability of outputs. Until some means are established to make these various inputs and outputs comparable in welfare terms, there is no basis for choosing between projects. This problem is essentially a valuation problem, and it is basically that of establishing suitable prices. Once the inputs and outputs of possible projects have been properly valued, it is possible to identify those which can make the greatest contribution to the welfare of society.

The third step is to select those projects which are to be executed. This step requires that methods be developed which will lead to the selection projects which make the maximum contribution to society's welfare, given the limitations on available resources. Application of the selection criteria will result in decisions to execute certain projects and reject the others.

If project analysis could be conducted without cost and without encountering some of the practical problems noted below, the ideal project planning system might operate as follows. First, the planner would assemble a large assortment of projects, with information for each consisting of the inputs and outputs or consequences of the project in physical, non-value terms. Second, he would apply prices to the inputs and outputs which would reflect their values to society, thereby reducing the physical data to a common unit reflecting the welfare of society. Third, he would compare the outcome in value terms of various combinations of projects and choose that combination for execution which maximized the returns on available resources. This process would be repeated regularly to take into account new technology, changes in factor supplies, etc., with a final selection being made each time on the basis of comparison between the outcomes of various combinations of projects.

In reality, project planning usually proceeds in a significantly different fashion. The final selection of projects is practically never made on the basis of a comparison between the outcomes of several different combinations. The decision to execute or reject a given project may be made well before detailed knowledge of the project has been worked up, and usually this decision will be made on an individual basis rather than as a part of a comparison process involving all other projects. Some rough screening takes place even at the project perception step. Some projects, while technically possible, are plainly not worth knowing in detail because they would never be worthwhile under any likely valuation system. An

example would be the growing of bananas in Korea. Other projects would need to be known only in rough terms. These would be projects which might be worth undertaking in the future even though they are not so currently. For example, one might consider exploiting minerals or forests in areas which are at present inaccessible. Rough calculations regarding costs and possible revenues can make it clear that projects of this nature are not currently beneficial and, consequently, they are not carried along in the planning process. Finally, other projects would need to be known in sufficient detail to make a definite decision as to whether they should or should not be undertaken, once a valuation system is given.

Ideally, the final decision to accept or reject particular projects should be made on the basis of as detailed and comprehensive information as possible. Furthermore, the decision should be held off as long as possible to permit the examination of alternatives. In practice, however, the decision to accept or reject, as noted above, is often made quite early in the planning process. It will often be made well before full information is available. Furthermore, where selection criteria are used, they are not conceptually equivalent to the third step of the ideal presented above but are, at best, only rough approximations.

As a practical matter, it is not possible to provide the information to carry out the ideal scheme presented above nor to make the sort of comparisons required in the ideal. Thus, a successful planning system will be one which balances the costs and practical difficulties of assembling data, calculating benefits and costs, utilizing selection criteria, and making all possible comparisons, against the benefits of coming closer to the choices which an ideal selection system would accomplish.

We will now examine the three steps of the project planning process in detail. Section III covers the first step, perceiving the project universe; Section IV covers the second step, evaluating projects in terms of social benefits and sacrifices; and finally, Section V covers the third step, selecting projects for execution.

III. STEP ONE: PERCEIVING THE PROJECT UNIVERSE

A. GENERAL CONSIDERATIONS

At any point in time the planner perceives a set of projects which might be undertaken. This set of projects is part of a universe consisting of all projects which conceivably could be undertaken. The extent of this universe of potential projects depends on existing technology, the natural resource base of the country and the skills and aptitudes of its people. In effect, full knowledge of the project universe would tell us all the goods and services that could be produced by the economy. Such a full perception of the project universe is an obvious impossibility, but clearly the wider the perception of the universe, the better the choice of projects is likely to be.

What information is required by the planner to perceive a project? Here is a point where ideal and reality are far apart. The ideal would be to know and measure quantitatively all the physical consequences of a given project which affected someone's welfare; i.e., all the resources that are used that result in a sacrifice on someone's part, and all the outputs that come into existence that provide utility, or disutility, to someone. Two things should be noted about this concept. First, in this step only the physical consequences are considered and not the effects on the peoples' welfare. Examples would be the quantity of cement used, the number of manhours of a particular labor skill required, the number of shoes produced, or the number of students taught. Relating these physical consequences to

the welfare of individuals or society is the second step of the scheme and will be discussed below.

Second, since the planner is to take the point of view of making choices in the interest of the entire society, he must know the consequences of a project throughout the economy, regardless of whether such consequences are directly or only indirectly connected with the project. In this regard, it is useful to note a classification of these consequences which relates to the view of the organizer and manager of the project. Is a particular consequence internal or external to the project; i.e., is the particular consequence something which those in charge of the project must take into account in their decisions about running it? In economic terminology, those consequences which would not be taken into account by the operators would be called external costs and benefits or external economies and diseconomies.

The internal-external division of consequences will be determined by the institutional rules which assign legal right or responsibility to the money revenues or costs arising from the project. Assuming that it is money costs and revenues that guide the operator's decisions about a project, those physical consequences which affect the money costs and revenues of the project will be internal, and those that do not will be external. Examples of internal costs would be the labor and capital used for which an outlay must be made; an external cost might be the pollution of a river caused by an industrial project.

The project planner, since he is presumed to be looking at projects from the point of view of society as a whole, will be concerned with both internal and external costs and benefits. Thus, he is expected to identify and take into account in deciding whether a project should be undertaken some consequences which would be of no concern to the project operator. The project planner should, for example, know to what extent a given project will pollute a river on which it is located, how it may stimulate the growth of other productive enterprises, or how it may contribute to peoples' welfare but be unable to collect revenue for this contribution. It is obvious from the examples that the identification and measurement of these external consequences is an exceedingly difficult task. Some, such as pollution, are purely the result of technological characteristics of a roject; some, such as cost savings to other industries, are felt through changes in market prices. However they are transmitted to the rest of the economy, they should be taken into account by the project planner.

At this point, the subject of external costs and benefits will be dropped. It will be picked up again below in the section dealing with the conversion of the physical consequences of a project into benefits and sacrifices of society's welfare. For purposes of step 1, it is sufficient to note that all physical consequences that affect society's welfare, whether internal or external to the project, must be taken into account by the project planner. Let us now consider some other problems of extending perception of that project universe.

B. BROADENING PERCEPTION OF THE PROJECT UNIVERSE

1. The Universal Shortage of Projects

It is practically a universal feeling on the part of economists with experience in the problems of development planning that one of the greatest difficulties facing the planner is the shortage of good projects.[1/] In the terminology of this section, the planner's perception of the project universe is limited. It follows that one of the areas in development planning which is most in need of improvement is the working out of procedures and techniques for increasing the perception of the universe of projects.

2. Developing Basic Knowledge for Project Perception

The perception of the project universe depends on two factors: (1) knowledge of the resources of the country, both physical and human, and (2) knowledge of the production possibilities of these resources. Knowledge of resources can come from surveys specifically undertaken for the purpose and from other sources which may have had reasons for collecting

---

1/ See, for example, Gordon, D. L., "Charting the Channels for Development Capital," Finance and Development, Vol. II, No. 2 (June, 1965), p. 79; Watson, A. M. and Dirlam, J. B., "The Impact of Underdevelopment on Economic Planning," The Quarterly Journal of Economics, Vol. LXXIX, No. 2 (May, 1965), p. 180; Inter-American Economic and Social Council, Planning and Project Formulation (Report of the Second Meeting of Special Committee I; Planning and Project Formulations, San Jose, Costa Rica), Washington, D. C.: Pan American Union, 1963, pp. 13-14; Schatz, S. P., "The Capital Shortage Illusion: Government Lending in Nigeria," Oxford Economic Papers (New Series), Vol. 17, No. 2 (July, 1965), pp. 309-316.

data on the country's resources. Knowledge of the production possibilities of resources depends on knowledge of technology. This sort of knowledge can come either from abroad or by research locally. Projects which are designed to increase both of these types of knowledge are what we have called class 3 projects. Well designed projects to cure deficiencies in these two areas should have high returns. Unfortunately, problems of measuring these returns make it exceedingly difficult to compare this type of project with others. This fact combined with the relatively long pay off of such projects has led to their relative neglect.

The deficiency of knowledge of both technology and resources can be remedied to some extent by importing technical assistance from abroad. However, while the use of foreign experts for this purpose has undoubtedly contributed to the increase of knowledge and specifically to the stock of worked out projects, it is plainly a temporary expedient which has significant disadvantages. Foreign technicians often have biases which arise from professional specialization, from connections with firms that might be hired to execute projects, and from original training which was oriented to conditions existing in developed countries. Furthermore, when such technicians leave a country, unless they have been engaged in training activities, the knowledge and the expertise in drawing up projects leaves with them.

The disadvantages of foreign technicians and their usual temporary stay suggest that they can make only limited contributions to widening the perception of the project universe. Long-run solutions to this problem

require different approaches. With the gradual awakening to this problem, some modest systematic efforts have been made to improve the situation. The regional commissions of the United Nations have made some contributions to its solution, but probably the two most important organizations working on this problem are the UN Special Fund and the International Bank for Reconstruction and Development.[1/] Their assistance has taken the form of organizing natural and human resource surveys, and similar projects to develop necessary basic information about the economies of various countries. The UN has also tackled the problem of transferring technical knowledge from the developed to the undeveloped countries. Its most impressive effort along these lines was the ambitious conference on the subject held in Geneva in February of 1963.[2/] In spite of these efforts it is still true that most underdeveloped countries lack adequate knowledge of their resources and their technical production possibilities.

3. Where-to-look-for-projects Approach

Thus far the discussion has centered on the basic knowledge necessary for perceiving possible projects, and we find that, while some efforts are being made to improve the situation, no substantial body of literature on

---

1/ Gordon, 1965.

2/ See the 8-volume United Nations report on this conference, Science and Technology for Development, United Nations, New York, 1963. The entire report is of interest for project planning, but the most relevant for the subject of building up knowledge of technology is Volume VII, Science and Planning.

the problem, at least as it relates to project analysis, has developed. A somewhat different approach to the problem is what might be called the where-to-look-for-projects approach. Most of the writers who have considered the problem have presented fairly general suggestions. For example, Bryce[1/] suggests that new opportunities may be identified by (1) studying present import patterns, (2) investigating local materials, (3) studying available skills, (4) analyzing existing industries, (5) applying current scientific and technical advances, (6) examining interindustry relationships, (7) evaluating the impact of development plans, (8) reviewing old projects, (9) observing experience elsewhere, and (10) using industry classification manuals as check lists. The United Nations project manual[2/] has a similar list of suggestions.

Bohr[3/] addresses himself somewhat more narrowly to the problem of finding suitable manufacturing industries to develop. He worked out rankings of industries based on capital requirements, skilled labor requirements, plant size and the possibility of plant dispersion. If these are the critical factors in determining suitable projects for developing countries, the obvious strategy is to devote attention to identifying

---

1/ Bryce, M. D., Industrial Development: A Guide for Accelerating Economic Growth. New York: McGraw-Hill, 1960, pp. 19-21.

2/ United Nations, Manual of Economic Development Projects. New York, 1958, pp. 8-9.

3/ Bohr, K. A., "Investment Criteria for Manufacturing Industries in Underdeveloped Countries," Review of Economics and Statistics, Vol. XXXVI, No. 2 (May, 1954), pp. 157-66.

projects within industries which scored well in Bohr's ranking system. Chenery[1/] has suggested another method for identifying industries which might be suitable for close attention for project purposes. He examined the growth of various industries in relation to income and size in a large number of countries and found historical patterns which could be described by suitable regression equations. Using these equations, a country could judge whether one of its industries was low, average, or high in output relative to income and size, judged by comparison with the historical development of that industry elsewhere. If the particular industry for the country were lagging, it would be a candidate for intensive study as a sector where worthwhile projects would be likely to be found. The implied assumption is that the historical patterns of other countries which were more developed would be suitable guides to the country in question.

One may have reservations about the assumptions which underlie Bohr's and Chenery's work, but they at least have the virtue of providing logical starting places for developing knowledge which should lead to better project perception. The utility of Chenery's method has not yet been demonstrated, but some experience has been gained in using techniques similar to Bohr's.

1/ Chenery, Hollis B., "Patterns of Industrial Growth," The American Economic Review, Vol. L, No. 4 (September, 1960), pp. 624-54. Chenery's work in this article was elaborated considerably in United Nations, Department of Economic and Social Affairs, A Study of Industrial Growth, New York, 1963.

An account of Puerto Rico's efforts along these lines has been given by Barton,[1/] and one for the British West Indies has been given by Lewis.[2/] These accounts are highly instructive, although the analysis is, of course, tailored to the conditions existing in the individual countries. Both were aimed at identifying industries in which profitable investments could be made which would also contribute increases in employment. The success of Puerto Rico's development program is well known. It is in no small measure due to the aggressive seeking of good projects which private business could undertake. Unfortunately, the experience in the British West Indies was not as happy, but the obstacles to development there have been outside the sphere of project analysis.

The suggestions cited above regarding ways to widen perception of the project universe go somewhat beyond our step 1 in that they direct attention to areas where projects are likely to be profitable and, hence, a rough sort of screening of projects is already involved. Step 1 in the three-step scheme, the perception of the universe of possible projects, stops short of any indication of profitability. It focuses on the problem of determining what is possible, not what is profitable. The distinction is worth making because what is profitable or beneficial depends on how one

---

1/ Barton, H. C., Jr., Puerto Rico's Industrial Development Program 1942-1960. Center for International Affairs, Harvard University, October 29, 1959.

2/ Lewis, A. W., "The Industrialization of the British West Indies," Caribbean Economic Review, Vol. 11, No. 1 (May, 1950), pp. 1-61.

values the resources used and the outputs gained, and if the valuations change, the net benefits will change, too. It is, therefore, quite possible that projects that are desirable under one set of evaluations will be undesirable under another and vice versa. A broad knowledge of possible projects, independent of the immediate valuations is desirable in order to permit the consideration of a large set of alternative projects when valuations change. This argument is absurd, of course, if pushed to its extreme. It is pointless, for example, to find out how to grow bananas in Korea, since it is unlikely that it will ever make sense to grow them there. However, it is not pointless to know something about the exploitation of the minerals of Antartica for example, since it may well become desirable to mine them in the future. In general, the broader the knowledge of possible projects, the more alternatives that can be considered and, presumably, the better the choices of projects to execute.

Step 1, as presented in its ideal form, treated the perception of individual projects as being total. Thus, all the physical consequences of a project would be known as the project became known to the planner. This ideal is, of course, impossible and would be wasteful to try to achieve because obtaining knowledge of projects is not a costless process. The examples in the previous paragraph show that the planner can proceed with considerably less than perfect knowledge of all projects. Decisions on some, such as growing bananas in Korea, can be made with very little detailed information and it would be wasteful to use resources in developing such

information. Clearly some sort of balance must be struck between intensive and extensive knowledge. Projects which show promise of being beneficial will require more extensive study than those that do not, but extensive study is necessary to suggest areas to which it is worthwhile devoting greater attention.

Two further criticisms may be noted concerning the suggestions for widening the perception of the project universe. The first is the obvious one that they are principally concerned with industrial projects. Hence, following them will produce class 1 projects but not much in the way of the other three classes. This gap in the literature is not surprising in view of the fact that the importance of the other three types has only recently been recognized. Clearly, methods need to be worked out for improving the perception of projects to increase non-capital factor supplies, to increase the supply of knowledge, and to bring about constructive institutional reforms.

The last criticism is somewhat more elusive. It concerns the conflict between these methods and certain characteristics of the development process which have come to be accepted as of critical importance. The problem revolves around the concept of interdependencies between projects. Different aspects of this problem have been examined by such writers as

Hirschman,[1/] Nurske,[2/] and Rosenstein-Rodin.[3/] Considerable dispute has arisen as to how the views of these writers can be reconciled but they would all agree with the central point that the success of most individual investments will be vitally affected by other projects. Yet the suggestions cited above largely ignore the question of interdependencies. Examining import lists and natural resource reports, for example, tends to concentrate on projects in isolation. This approach is essentially conservative for it does not include the positive effects of other investments which may very well provide the margin of success of a given project. Thus, if the sort of suggestions given above are followed, it may very well lead to the failure to examine carefully projects which would succeed in the context of a full development program.

This section will be closed by referring once more to the Fomento program of Puerto Rico. A key element to its success was the widening of the perception of projects. Other factors were important in this program

---

1/ Hirschman, A. O., The Strategy of Economic Development. New Haven: Yale University Press, 1958.

2/ Nurske, R., Problems of Capital Formation in Underdeveloped Countries. Oxford: Blackwell, 1953.

3/ Rosenstein-Rodin, P. N., "Problems of Industrialization of Eastern and South-Eastern Europe," Economic Journal, Vol. 53 (June-September, 1943), pp. 202-11.

but, without doubt, the inclusion of an aggressive program of finding investment opportunities which could be undertaken by private investors contributed heavily to its success. The means by which these opportunities were sought were much the same as those cited above.[1/] For all the deficiencies of these methods, good opportunities were found, good enough to attract many private investors from outside Puerto Rico. Regardless of the type of investor, the lesson seems clear: Significant attention to the problem of widening the perception of the project universe can pay handsome returns in a development program. In what follows we do not feel that the problem of resource allocation between projects in classes one to four is handled in a satisfactory way. We feel confident that in most countries substantial increases in resources devoted to identification of projects in any of the four classes would be sound development practice.

1/ Barton, H. C., 1959.

IV. STEP TWO - TRANSLATING PHYSICAL CONSEQUENCES OF PROJECTS INTO SOCIAL BENEFITS AND SACRIFICES

The second step in the project planning scheme is the translation of the physical outcomes of projects into some measure of social benefits and sacrifices. A way must be devised to relate the diverse physical consequences of projects to social welfare. As noted earlier, this is basically an evaluation problem. A suitable unit must be chosen which will make the physical consequences commensurable, and prices must be established which reflect the changes in welfare associated with various projects. Since welfare is basically a state of mind, it cannot be measured quantitatively in any direct fashion. We assume, however, that a unit can be found and values established in this unit so that when the value of one project is greater than for another, we can say welfare is greater for the first than the second. The unit used for this purpose is, of course, money, but the problem of establishing prices in order to arrive at an appropriate social evaluation has been the source of controversy in economics for two centuries. A brief examination of some aspects of this controversy will provide an insight to the problems of project analysis and should lead to a better understanding of the limitations of currently utilized methods.

A. EVOLUTION OF COMPETITIVE PRICE THEORY

1. The Labor Theory of Value

One of the earliest valuation systems was the Ricardian labor theory of value. Ricardo, writing in the early 19th century, maintained that the value of goods and services was determined by their labor content. Ricardo's labor value theory was subsequently elaborated by Karl Marx. In the Marxian system, value was determined by the amount of socially productive labor required to produce individual goods and services. Marx said that the socially useful labor content of goods and services literally measures their value to society. Hence, this value should be exactly what is needed for project analysis purposes. In practice, communist countries have found the labor theory of value unworkable and have not used it for purposes of setting prices or for choosing investment projects. Instead of reflecting labor content, prices generally are set to control the distribution of goods and services. This state of affairs has been a source of controversy and embarrassment in Russia, but at the present time the defenders of the labor theory of value seem definitely to be losing ground.[1/] Elsewhere in the communist world there seems to be clear movement towards the use of prices which are based on marginal costs.[2/] These prices are related to the second

---

1/ Zauberman, Alfred, "The Soviet Debate on the Law of Value and Price Formation," in Grossman, Gregory, (ed.), Value and Plan, Economic Calculation and Organization in Eastern Europe. Berkeley: University of California, 1960.

2/ Montias, J. M., "Producer Prices in a Centrally Planned Economy," ibid.

valuation system which will be discussed here, that based on marginal utility.

2. Marginal Utility Theory of Value

In the second half of the 19th century, the Austrian marginal utility school provided the basis for current economic theory concerning value. Modern theory has retreated considerably from the original formulation which relied on a concept of measurable utility. The retreat seems well taken since measurable utility is a highly questionable concept. Certain aspects of the original formulation will be presented here, however, because much that has been written on pricing for project analysis purposes is based implicitly on such a concept. Once the relevant parts of the original formulation have been presented, the retreat will be examined.[1/]

The marginal utility theory of value provides a direct connection between market prices and the utility to society of the goods and services which are exchanged. Utility in this context can be equated to the welfare level which we are seeking to measure. If such a connection between prices in this system and utility to society could be established, the prices of this system would be appropriate for valuation of goods and services in

---

1/ The discussion which follows of utility and value theory is the standard treatment of the subject to be found in most economic theory texts. Those familiar with this theory may skip this argument without loss of continuity. It is included here because it is essential to an understanding of the pricing problem of project analysis. The version given here is substantially that given first by Alfred Marshall in his Principles of Economics. References to Marshall's Principles will be to the eighth edition, London: Macmillan, first printing, 1920.

project analysis. The argument went roughly as follows: The utility of a good or service to an individual can derive either from the direct utility enjoyed from its use or indirectly from the utility of something else for which it might be exchanged. In general, the more one has of a particular good, the greater the total utility derived from that good. However, as one adds units, the utility derived from the last or marginal unit is less than that of earlier units. This is an appeal to the so-called Law of Diminishing Marginal Utility. An individual will arrange his purchases from a given income so as to make equal the utility of the last dollar in each particular use; i.e., make equal the marginal utility per dollar in all uses. The marginal utility per dollar in any use is simply the ratio of its marginal utility to its price. Hence, the rule can be stated mathematically as:

$$\frac{MU_1}{P_1} = \frac{MU_2}{P_2} = \ldots \frac{MU_n}{P_n}$$

Clearly, if this equality does not hold, the individual can increase his total utility by shifting purchases from those goods and services with low MU per dollar to those with a higher ratio. But in shifting purchases, the MU of those with high ratios will fall and that of those with low ratios will rise. Hence, the ratios will move towards each other. When they are equal in all uses, the individual will have reached the maximum total utility which he can secure from a given income.

It has been assumed thus far that this individual faces given prices in his decisions about purchases and sales. If the price of a good or service changes, the ratio of marginal utility to price will change and he will be led to change the amount purchased until the marginal utility-price ratio is again the same as for other goods and services. In so doing he will adjust his purchases to maximize his total utility given the new price. By presenting the individual with a schedule of prices for a good and noting the quantity which he would purchase, we could find his individual demand curve for the good. This concept is illustrated in Figure 1. The individual will purchase one unit at price $15, a second unit at $12, a third at $10, a fourth at $9, and a fifth at $8. It is apparent that if the purchaser

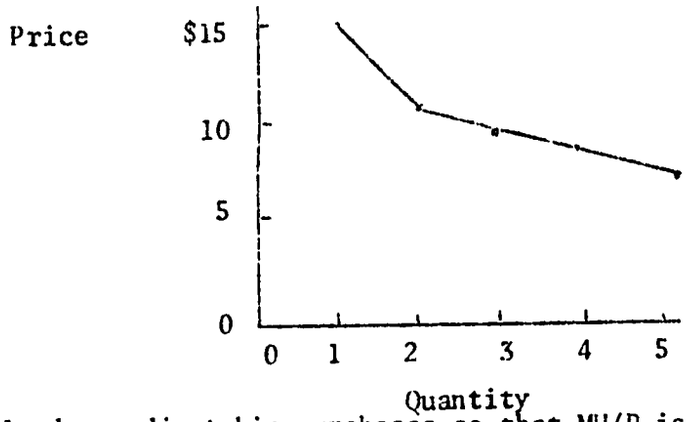

Figure 1

really does adjust his purchases so that MU/P is the same as for all other goods (here assumed to be constant),[1/] he will buy each additional unit at a

---

1/ The entire argument of this paragraph depends on the assumption that MU/P is constant. Marshall accepted this assumption; Hicks later defended it. See Hicks, J. R., "The Rehabilitation of Consumers Surplus," The Review of Economic Studies, Vol. VIII, No. 2 (February, 1941), pp. 108-16.

price which is directly proportional to the utility of that unit. Thus $15 measures the utility of the first unit, $12 that of the second, $10 that of the third, $9 that of the fourth and $8 that of the fifth. Evidently the total utility of five units would be measured by the sum of these five marginal values, $54. This is the same as the area beneath the demand curve out to the quantity demanded.

The demand curve examined above is that for one individual. To obtain the demand curve for a whole market, the individual amounts demanded at various prices would be summed for each price and the total amount demanded at each price established. A curve similar to that in Figure 1, but out to the right at larger quantities, would result.

If the assumption is now made that the utilities of individuals are of equal weight and can be added to each other, it is possible to draw some conclusions about utility for the community as a whole. Since all individuals in the market are adjusting to the same price; i.e., at any given price each chooses the quantity demanded to equalize his own marginal utility-price ratios, the price must measure the marginal utility of the group as a whole. Furthermore, using the same argument as that used for an individual, the total utility would be measured by the area beneath the demand curve out to the quantity demanded.

A similar line of argument would establish individual and market supply curves for a good. In this case the curve is conventionally shown to slope upward since the greater the quantity sold, the greater the sacrifice of utility for the last or marginal unit. (Where technological

economies of scale exist, it might slope downward.) The price at which a given amount would be sold would now measure the utility sacrificed by giving up the marginal unit, and the area beneath the curve out to the quantity sold would measure the total utility sacrificed by the scale of that quantity.

The supply and demand curves for the entire market are shown in Figure 2.

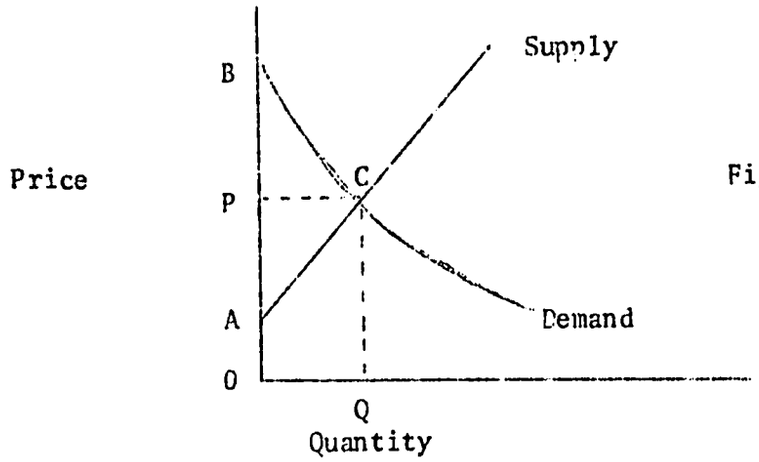

Figure 2

The equilibrium price and quantity would be OP and OQ, respectively. This is the price at which both buyers and sellers are satisfied with the quantity exchanged. In accordance with the argument presented here, the price OP measures both the marginal utility gained and that sacrificed by purchasers and sellers, respectively, since they both face the same price. OBCQ measures the total utility gained by the buyers and OACQ the utility sacrificed by the sellers, and the difference between the two, ABC, is presumably a measure of the net gain to society from the exchange.

We have noted that individuals will attempt to maximize their utility by arranging their purchases and sales of goods and services so as to equate the marginal utility of a dollar's worth of purchases or sales in all possible uses. If all individuals follow this guide, and no one individual has enough influence on a market to affect its price, the aggregate effect will be to establish an equilibrium set of prices for the entire economy which measures the marginal utility of each good and service for society as a whole. Since the values which these prices establish are directly related to marginal utilities, the name marginal utility theory of value is appropriate.

The prices which are proportional to society's marginal utilities will be established if markets are perfectly competitive. Under these conditions, the same marginal conditions which each individual establishes for himself will hold for society as a whole. Hence, society as a whole will achieve maximum utility or welfare by virtue of its individuals attempting to do so for themselves. If any individual were to shift his purchases once this equilibrium had been established, his utility would fall and so would that of society. The allocation of resources which this system produces is an optimum, therefore, given the current resources, tastes, and distribution of income.

3. The Time Dimension

The optimum of the previous paragraph is subject to a number of highly destructive criticisms. Further, the prices which exist in such a system may not be the ones which the project planner needs because they reflect only marginal utilities, not total utilities. However, before examining the deficiencies of this model, it needs to be extended to include time as a dimension of the problem. As described above, the optimum is a static, timeless concept. It is, as it were, a picture of the entire economy in a timeless equilibrium where everyone is acting so as to maximize his own welfare, and no one desires to change any of his decisions. However, we live in a world in which time is an important dimension. Both producers and consumers are faced with the decisions not only about distributing current income among various possible uses for the present but also the choice of distributing purchases and sales over time.

The introduction of time does not alter the basic concept radically. Consumers and producers still attempt to maximize their individual utility or welfare, but they-must now take into account the possibilities of future goods and services. The problem is that at any given point in time, individuals will probably value particular goods and services if expected to be received in the future at something less than the same goods and services received in the present. While it is conceivable that some individuals would have perverse preferences in this respect, it seems reasonable to expect that most individuals would prefer goods and services

in the present to those in the future. This phenomenon is called time preference; i.e., the preference for having goods in the present as opposed to having them in the future.

Time preference leads individuals to place a lower money value on goods to be received in the future, as compared to the same goods in the present. This difference in money values between present and future as seen at any one point in time is called time discount, and this discount when reduced to an annual percentage rate would be called the individual's time preference rate.

Time preference provides part of the mechanism by which savings and investment decisions are to be made. It permits the valuation of future income as compared to present income. Clearly if an individual is to sacrifice present income for the promise of future income, the future income must be enough larger than present income to counter-balance one's time preference. Thus the time preference rate would be the price, stated as an annual rate, which an individual would require in order to induce him to part with current income on the promise of future income. This act is, of course, saving.

On the other hand, producers find that the use of capital permits production at lower cost than would otherwise be the case. Hence, they are in a position to pay the saver a premium for his savings. Producers will borrow funds to finance capital accumulation up to the point that the increased productivity due to the capital is no longer greater than the price paid savers.

We now have the two sides of an additional market in the economy, the market for capital funds. The supply will come from savers and will depend on time preference; demand will come from producers and depend on the productivity of capital. The price in this market is the interest rate; i.e., the cost of borrowed funds. It can be shown,[1/] for a finite time horizon, that when this price, as well as all other prices in the economy, is established in a competitive market, a welfare maximum or optimum will exist for the society. This optimum has the condition that no one can redistribute his current purchases and sales and his lending or borrowing in such a way as to increase the total discounted utility as locked at today. The interest rate is the price which determines the application of current resources for future production; i.e., the accumulation of capital. The accumulation of capital determines the growth rate. Hence, the general optimum discussed here implies an optimum growth rate for the economy, on the previous assumption that the individual utilities add to form the social utility.

B. SHORTCOMINGS OF COMPETITIVE PRICES FOR PROJECT ANALYSIS

The point has been reached in the argument where it is concluded that if the assumptions which are required about utility, markets, income distribution, etc., are met, a system which allocates its resources according

---

1/ See, for example, Henderson, J. M., and Quandt, R. E., Microeconomic Theory, A Mathematical Approach, New York: McGraw-Hill, 1958, Chapter 8.

to competitive prices will achieve the socially desired optimum production pattern. If a project planner allocates those resources which he controls using these prices, he will simply be helping to achieve this optimum, and he will be making the maximum possible contribution to society's welfare.[1/] Thus, the conclusion is reached that he should use competitive prices for purposes of project evaluation. This advice has indeed often been given to development planners, in one guise or another. However, the use of competitive prices is surrounded by a host of difficulties, both practical and theoretical. There are so many that one despairs of treating them in any organized fashion. We will attempt to establish some order by grouping our comments under seven general topics. These topics are (1) time preference and social welfare, (2) external economies and diseconomies, (3) income distribution, (4) attempts to avoid the use of the utility concept, (5) finding the theoretically correct prices, (6) failure of marginally determined prices to reflect total benefits, and (7) finding prices for non-marketed outputs.

1/ Competitive prices are sometimes referred to as marginal cost prices, for the industry supply curve is essentially its marginal cost curve. An exposition of the connection between the industry supply curve and the cost curves of the firms in the industry has not been included here since it is not necessary to the argument. For a full elaboration of this point, see Lerner, A. P., The Economics of Control, Principles of Welfare Economics, New York: Macmillan, 1944.

1. Time Preference and Social Welfare

The subject of time preference has been treated briefly above. It is, however, both important enough and controversial enough to require further examination. Major contributions on the subject have been made by Feldstein,[1/] Marglin,[2/] Eckstein,[3/] and Harrod.[4/] Much of the following discussion is based on Feldstein's work.

Time preference is at the heart of project analysis, for it attempts to solve the problem of comparing sacrifices and benefits which occur at different points in time. A satisfactory solution to this problem is of crucial importance for project evaluation. In order to understand the

---

1/ Feldstein, M. S., "The Social Time Preference Rate in Cost-Benefit Analysis," The Economic Journal, Vol. LXXIV, No. 294 (June, 1964), pp. 360-79; "The Derivation of Social Time Preference," Kyklos, Vol. XVIII, Fasc. 2 (1965), pp. 277-87.

2/ Marglin, S. A., "The Social Rate of Discount and the Optimal Rate of Investment," The Quarterly Journal of Economics, Vol. LXXVII, No. 1 (February, 1963), pp. 95-111.

3/ Eckstein, Otto, "A Survey of the Theory of Public Expenditure Criteria," in Public Finances: Needs Sources and Utilization, Princeton: Princeton University Press, 1961; "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics," The Quarterly Journal of Economics, Vol. LXXI, No. 1 (February, 1957), pp. 56-85; Water Resource Development: The Economics of Project Evaluation, Cambridge, Harvard University Press, 1958.

4/ Harrod, Roy, Towards a Dynamic Economics, London: Macmillan, 1948.

controversy which surrounds the subject of time preference, it is necessary to begin by considering the more general question of the nature of social welfare. We have accepted the premise that the fundamental task of development planning is to maximize social welfare, but up to this point no careful examination of this concept has been made.

In the discussion of section A above, it was assumed that the utilities of individuals are measurable and can be added to each other to obtain total community or social utility. Social utility, therefore, depends only on how much utility individuals enjoy from the goods and services which they themselves possess. It is reasonable to expect, however, that one's well-being or welfare would be affected by additional economic factors such as relative position in the income distribution, what others are consuming, etc. Such a broad notion of welfare has been proposed under the title of the social welfare function.[1/] The difficulties with the concept of a social welfare function are formidable in the timeless case, but they are overwhelming when time is introduced. Therefore, while it would be desirable to work with a more general welfare function, we are forced to restrict the inquiry to the utility which individuals derive from goods and services alone.

1/ For an excellent treatment of the social welfare function, see Samuelson, Paul A., Foundations of Economic Analysis, Cambridge: Harvard University Press, 1948, Chapter VIII.

In another direction, it would be desirable to avoid the assumption of measurable utility. Some efforts to avoid measurable utility are discussed below in section 4. Again, however, when the time element is introduced, avoiding measurable utility becomes overwhelmingly difficult. We continue, therefore, the assumptions of measurable and additive utility.[1/]

The utility which individuals attach to particular goods and services derives either directly from the pleasure of consuming them or indirectly from the pleasure of consumption goods or services for which they can be exchanged. Thus, it is reasonable to use consumption over a given time period as the basic variable upon which social utility will depend. However, project planners will not just be interested in consumption during the current period, for investment decisions in the present will affect future as well as current consumption. The goal would be to choose those projects which directly or indirectly contributed most to the consumption stream over time. The problem at hand is how to evaluate that consumption stream and the contribution of individual projects to it. As will be seen shortly, a satisfactory answer will actually accomplish an additional aim; it will, in conjunction with the productivity of capital, show how much should be

---

1/ Practically all writers who have dealt with time preference for society have been forced to make assumptions similar to those noted above. C.f., Feldstein, 1964, p. 371. For a spirited declaration that the measurement problems are not insuperable, see Frisch, R., "Dynamic Utility," Econometrica, Vol. 32, No. 3 (July, 1964), pp. 418-24.

saved from current income and invested. While the latter problem is not immediately relevant to the evaluation problem, the two are so interdependent that they must be discussed together.

To proceed with the problem of evaluation of consumption streams over time, let us consider all possible consumption paths. Such paths may be represented by a series of numbers C_0, C_1, C_2....which give consumption in each year. Figure 3 represents three such paths (which are drawn as continuous curves for ease in visualization) labelled M_1, M_2, and M_3.

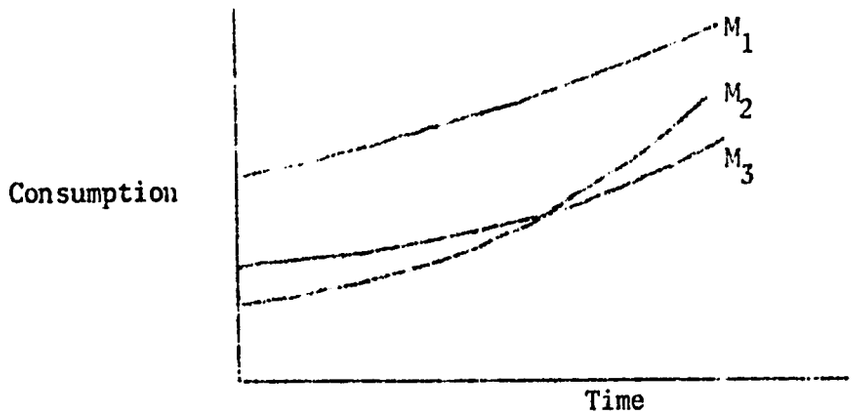

Figure 3

M_1 is clearly the best of the paths, since at every point of time consumption along the M_1 path is higher than on M_2 or M_3. However, it is not clear which of M_2 or M_3 is preferable to the other. In comparing M_2 and M_3, M_3 provides more consumption in the early years but less in the later years. It is conceivable that one society might prefer M_2 to M_3 and another might prefer M_3 to M_2. That is the first society is prepared to accept some reduced consumption now in order to get more in the future, while the second prefers to consume more now even though there will be less in the future than would be the case if less were consumed in the present.

Let us now define the social time preference function as the relationship by which society assigns current values to future consumption. In other words, the social time preference function tells us what value, as of the present, society would put on any given stream of consumption from now to an infinitely distant time period. Formally, this may be written in the general mathematical form:

$$\text{(IV.1)} \qquad V = V(C_0, C_1, C_2, \ldots\ldots\ldots\ldots),$$

where V is the present value to society of the consumption stream represented by the C's. The equation simply says that this present value is some unspecified function of current and future consumption. If the specific relationship were known, the planner could evaluate any possible stream of consumption by substituting the C's into the relationship. Thus, he could evaluate the two consumption streams M_2 and M_3 and make a clear choice between the two which would reflect society's preferences.

We will accept the fact that the specific relationship really is unknown. However, the factors which would enter into such a function can be examined, and a few simple forms can be suggested.

Feldstein[1/] suggests that four important elements should be taken into account in the social time preference function: (1) the increase in

---

1/ Feldstein, 1965, p. 278. His work is stated in terms of the social time preference rate rather than STP function. This difference is of no importance for purposes of the above discussion.

consumption which individuals enjoy due to an increase in aggregate consumption; (2) the increase in utility which individuals will enjoy due to the increase in individual consumption; (3) the increase in aggregate social utility due to the increase in individual utilities; and (4) the increase in current value due to the increase in social utility in a future year. These factors suggest respectively that (1) income distribution may affect the STP function; (2) diminishing marginal utility may mean that utility rises proportionately more slowly than consumption; (3) social utility may not be the simple sum of individual utilities, with the consequence that doubling the population at the same level of per capita consumption may not double social utility; and (4) there may be so-called "pure time preference" which leads to discounting future utilities.

Before proceeding to examine a possible STP function, an additional definition is necessary, that of the social time preference rate. The <u>social time preference rate</u> is defined formally as the proportion by which the present value, V, will rise for a given increase in consumption in one period as compared to the rise in V for the same size-increase in consumption in the following period. This may be expressed mathematically as:

$$\text{(IV.2)} \qquad \text{Time preference} = \frac{\partial V/\partial C_n}{\partial V/\partial C_{n+1}} - 1.$$

The numerator of the fraction, $\delta V/\delta C_n$, is the change in present value associated with a change in consumption in period n; and the denominator, $\delta V/\delta C_{n+1}$, is the change in present value associated with a change in consumption in the following period, n + 1. As would be expected, the measure gives a social time preference rate of 0 when the effect on present value of a given consumption change is the same in both time periods. It is positive if the present value is felt to be increased more when the consumption increase is in the earlier time period (n) than when in the later (n + 1), and negative if the reverse relationship holds.

With the formal definitions in hand, we may now consider some possible forms that the social time preference function might take. The analysis of the properties of social preferences over sets of consumption paths is a relatively new field.[1/] What is known about such preferences is not very helpful to the planner. We are obliged, therefore, to assume a particular functional form.[2/] Perhaps the simplest is the sum of consumption, $\sum_{t=0}^{N} C_t$. N would represent the horizon of the society in looking towards the future. There is no real reason for N not to be infinite; who is prepared to say that the level of consumption in a thousand years is of no interest

---

1/ See Diamond, P. S., "The Evaluation of Infinite Utility Streams," Econometrica, Vol. 33, No. 1, (January, 1965), pp. 170-77.

2/ See Radner, Roy, Notes on the Theory of Economic Planning, Athens; C. Serbinis Press, Center of Economic Research, 1963, Chapter 2.

to us? Once, however, we have put $N = \infty$, in this representation we are faced with a fundamental difficulty: the present value will be infinite (i.e., the sum diverges). A further characteristic of this function is that social time preference is zero. The combination of zero time preference and an infinitely distant horizon would clearly give the result of present value being infinite. It has indeed been argued that any positive non-zero time preference is unfair since it short-changes the future by giving it less weight than the present.[1/] However, if the STP rate is zero, it makes no difference how much one consumes or saves, since the present value is infinite regardless of saving decisions. Under these conditions, if capital continued to have a positive marginal productivity, no matter how much was invested, a society might be led to save all current income and invest it, since it would produce more consumption later. This is, of course, nonsense. Assuming that the goal is to maximize present value to society, it makes no sense to go further than saving enough to make V infinite, and it is not necessary to save all income at any time in order to make ΣC_t infinite. Unfortunately, practically any saving pattern will make the STP function infinite when the future is counted the same as the present; hence, this form is of no use for determining the appropriate savings and investment level. Let us, therefore, consider a form of the STP function which gives

---

1/ Dobb, M., An Essay on Economic Growth and Planning, London: Routledge and Kegan Paul, 1960, Chapter 1. Implicitly this is also the assumption in Horvat, B., "The Optimum Rate of Investment," The Economic Journal, Vol. 68, (December, 1958), pp. 747-67.

more weight to the present than the future:

$$\text{(IV.4)} \qquad \Sigma d_t C_t$$

where the d_t are weights for the individual periods. If the weights d_t approach zero sufficiently fast as t increases, the sum will converge; i.e., will not be infinite, for some consumption paths. The declining weights could be the result of positive pure time preference, diminishing marginal utility as higher consumption levels are reached, or perhaps other factors. If the weights for distant times are very small, our instinctive belief in a positive time preference is satisfied and the distant future will be considered to be of less importance than the present. But what pattern is reasonable to assume for the declining weights? Again, it must be admitted that the true form for these weights, if there actually is one, is not known. However, a reasonable one which is also very convenient for mathematical purposes is the following:

$$\text{(IV.5)} \qquad d_t = \frac{1}{(1 + r)^t}$$

The STP function, with these weights, becomes:

$$\text{(IV.6)} \qquad V = \sum_{t=0}^{\infty} \frac{C_t}{(1 + r)^t}$$

The social time preference rate as defined in (IV.2) would in this relationship be equal to r for all periods. It is particularly convenient for this reason. There are some assumptions, however, that may not be entirely acceptable. The important ones are (1) the constant STP rate, noted above; (2) there is no diminishing marginal utility for higher levels of C; and (3) the present value of any one C is independent of all others.

The STP function of (IV.6) assumes that the utility that accrues in time t is measured by C_t, and the utility which accrues to society over its existence from the present on, is evaluated by the present generation as $\sum_{t=0}^{\infty} \frac{C_t}{(1 + r)^t}$; however, this tells us nothing of welfare at any particular time. To the extent the society feels responsibility for the future, the weights d_t attached to future consumption will be high; i.e., the social discount rate will be low. This responsibility for the future, if acted on, does, however, reduce the utility which will be obtained in the present period; if one felt no responsibility for the future, then one would not bother to save to enable increases in output in the future. Practically speaking, since generations of people overlap, each prevents the others from using up the nation's resources with no eye to the future. Furthermore, it has been argued, cooperative efforts between people increase their

willingness to give more weight to the future.[1/] In any event, social interaction will tend to affect the individual time preferences.

A critical point has been reached in the argument. Given the various assumptions which have been made, the device for evaluating the inputs and outputs of projects is in hand. If the inputs and outputs are correctly priced for the period in which they are used or produced, these values can be converted to present values by use of the same discount factor as in (IV.6). Thus, knowledge of the social time preference rate will permit the evaluation of future benefits and costs in the present on a comparable basis. The next question logically is, How does one estimate the social time preference rate?

Determination of the social time preference rate is no simple task. Cookson[2/] has argued that the growth rate corrected for population growth should equal the social time preference rate. From this proposition, he deduces an STP rate of 2-3% for countries currently growing at 5%.

1/ Marglin, S. A., 1963; Sen, A. K., "On Optimizing the Rate of Saving," The Economic Journal, Vol. LXXI, (September, 1961); Marglin, S. A., "Economic Factors Affecting System Design," in Maass, A., (ed.), Design of Water Resource Systems, Cambridge: Harvard University Press, 1962; on overlapping generations see: Samuelson, P. A., "An Exact Consumption-Loan Model of Interest With or Without the Social Contrivance of Money," Journal of Political Economy, Vol. 66, No. 6, (December, 1958), pp. 467-82.

2/ Cookson, Forrest C., Jr., "Notes on the Theory of Project Analysis," to be published by Center for Development Planning.

Another approach relies on observed interest rates. It can be shown that in a perfect capital market, the time preference rate would equal the productivity of capital and the interest rate (corrected for depreciation). Some guidance could be expected from this source. The following relationship between the interest rate (r), productivity of capital (r_o), and life time of a capital good (T) is easily established:[1/]

$$r_o = \frac{r}{1 - e^{-rT}}$$

For typical values of r_o and T we can calculate r. The interest rate will equal the social time preference if the government is borrowing enough to raise total investment to the right level. The observed interest rate would reflect many market imperfections as well as government monetary policies which are directed at stabilization rather than growth. However, from r_o and T, the productivity of capital and the lifetime of capital goods, the interest rate can be determined and, hence, time preference, which would hold in the absence of market imperfections. For values such as r_o = 8%, T = 15 years, we find approximately 3% for the time preference rate.

1/ The discounted value of the stream $\$r_o$ for an investment of $1 is:

$$\int_o^T r_o e^{-rT} dt = r_o \frac{(1 - e^{-rT})}{r}$$

In equilibrium in the capital market this will equal the cost of capital. Therefore:

$$r_o = \frac{r}{1 - e^{-rT}}$$

Marglin[1/] has pointed out, however, that individuals might be willing to accept a time preference rate for society as a whole which is different from their private preferences, provided everyone was obliged to abide by it. Under these circumstances a market rate established in perfect markets could be different from a rate established by a political process acceptable to the population. This possibility, and the imperfect nature of most capital markets, make the observation of market rates of limited use in establishing a suitable social time preference rate.

Eckstein has presented two other approaches to the determination of time preference. One method is based on survival probabilities from mortality tables. This method shows time preferences between 1 and 5% for India.[2/] Presumably, as population grows more rapidly and the age distribution shifts towards a higher percentage of young people, the time preference rate will fall. The other argument is based on the declining marginal utility of consumption; if per capita consumption is growing at a given rate, the interest rate (time preference) will be such as to equal the ratio of the marginal utilities of consumption in consecutive years.[3/] If one knows the marginal utility of per capita consumption, then it is possible to calculate the time preference.

1/ Marglin, 1963.

2/ Eckstein, 1952, 1957.

3/ Eckstein, 1961; Harrod, Roy, 1948.

In both cases, there is a presumption that the rate of time preference will change in time. There is nothing that keeps us from incorporating a changing time preference rate into the social time preference function; it will mean that the weights d_t do not all have the same ratio. Thus, as we look further into the future, the social discount rate might be rather different than it is now. No essential change is introduced when we have a changing rate of social time preference.[1/]

This section has attempted to present the basic issues of time preference as they relate to benefit evaluation. The subject is an extremely complicated one; and to reach relatively simple results, a number of shaky assumptions had to be made. But time preference is so much at the heart of project evaluation that one cannot afford to throw up one's hands in despair. It is undoubtedly true that ignoring the problem will give bad results. We may say, hopefully, that the estimates of the STP rate will be refined. If so, the simplifications introduced in practice will make the problem manageable and will give satisfactory results.

1/ It is worth noting that the condition given above for optimum growth is for social time preference to equal the growth rate. The condition of a perfect capital market is that social time preference must equal the marginal productivity of capital; finally we have the condition that the marginal productivity equals social time preference equals growth rate. This is just the "golden rule" derived from the demand side; see Phelps, E. C., "The Golden Rule of Accumulation: A Fable for Growthmen," American Economic Review, Vol. 51, No. 4 (September, 1961), pp. 638-43.

2. External Economies and Diseconomies

In the section on project perception it was noted that the project planner should pay attention to the external consequences of projects as well as the internal ones. One of the assumptions of the system which leads to an optimum with competitive prices is that there are neither external economies or diseconomies. Scitovsky[1/] has written perceptively on this subject. He points out that there are two basic kinds of external economies, technological and pecuniary. Technological external economies and diseconomies are external consequences which are tied to the production of some good or service by a technological relationship. Such a relationship exists when the change in production of one good brings about a change in the production of another because of some technical relationship not felt through the market mechanism. An example is the effect on the output of a beehive which the establishment of an orchard nearby would have. Water and air pollution are examples of external technological diseconomies, albeit somewhat more general in external effects than the bee-orchard example. Clearly, since these effects are outside the market system as usually

---

1/ Scitovsky, T., "Two Concepts of External Economies," Journal of Political Economy (April, 1954). See also Arndt, H. W., "External Economies in Economic Growth," Economic Record, Vol. XXI, No. 61 (November, 1955); Reiter, G., and Sherman, G. R., "Allocating Indivisible Resources Affording External Economies or Diseconomies," International Economic Review, Vol. 3, No. 1 (January, 1962); Malgren, H. B., "Balance, Imbalance, and External Economies," Oxford Economic Papers (New Series), Vol. 15, No. 1 (March, 1963), pp. 74-9; Mishan, E. J., "Reflections on Recent Developments in the Concept of External Effects," The Canadian Journal of Economics, Vol. XXXI, No. 1 (February, 1965), pp. 3-34; Moore, F. T., "Economies of Scale: Some Statistical Evidence," Quarterly Journal of Economics, Vol. LXXIII, No. 2 (May, 1959).

conceived, they will not be reflected in market prices. Hence, competitive prices would not reflect the full benefits or costs to society. If such external economies or diseconomies exist and are of significance, they quite clearly should be taken into account in decisions about projects when considered from the viewpoint of society. The second type of external economies would be pecuniary; i.e., they are felt through market prices rather than through a technical relationship. Two industries using each other's products and subject to economies of scale will illustrate the difficulty. If A increased output, its costs and price would fall and production in B would be more profitable; similarly, if B increased output, its costs and prices would fall and A would be more profitable. Both would be better off at greater output, but lacking the knowledge that the other's price would fall if output were increased, neither has an incentive to expand. Thus, competitive prices in A and B do not lead to the best allocation of resources.

The point of the previous paragraph is sometimes made by saying that the competitive equilibrium does not yield an optimum when there are significant economies of scale. Internal economies of scale for an industry will be pecuniary external economies for other industries; hence, the two formulations are the same.

Scitovsky[1/] notes that pecuniary external economies are surely common in underdeveloped countries and are of considerable practical significance. (He also expresses the opinion that technological external economies and diseconomies are of little significance, but this opinion seems not to be so widely held as that concerning pecuniary external economies.) It would be highly desirable to take such external consequences into account for a project, but it is a matter of considerable practical difficulty to do so. As noted in Part III above, currently used methods of hunting for good projects have a tendency to overlook this kind of external effect.

3. Income Distribution

The conclusion that competitive prices yield a maximum level of welfare is subject to another assumption that the distribution of income and wealth is taken as given. If the planner's goal is to reach the maximum welfare level possible for society--not just the best possible with a given distribution of income but the maximum-maximorum--his problem is two-fold: First, he must arrange for the distribution of income, and, second, he must arrange for the allocation of resources after the redistribution of income. In order to accomplish the redistribution, some

---

1/ Scitovsky, 1954.

sort of system of subsidies and taxes would presumably be used.[1/] Once the system of subsidies and taxes had been imposed, there would be some set of prices--different from the earlier set of prices--which would reflect the appropriate allocation of resources to reach the new maximum welfare position. Assuming that the redistribution actually takes place, the project planner obviously should use the prices for project evaluation purposes which reflect the distribution of income after subsidies and taxes. While it is conceivable that the effects of transfers of income on prices would cancel out, it is highly unlikely that this would be the result. Particularly where the income distribution was modified by reducing those with high incomes and increasing those with low incomes, one would expect substantial shifts in demand patterns. Consequently, the prices that would obtain after redistribution would be quite different from those which obtained before redistribution. Hence, historical prices even in competitive markets would not necessarily be the correct ones to use for project analysis when a development program was being undertaken which substantially modified income distribution. Needless to say, the practical problems of predicting prices after a substantial income redistribution would be very great.

1/ Establishing a suitable tax-subsidy or other program which would redistribute income successfully would be a tremendous task. We acknowledge this fact and make no effort here to survey the problems involved.

4. Attempts to Avoid the Use of the Utility Concept

Two particularly vexing problems which were raised by the utility formulation of value are the legitimacy of assuming measurable utility, and of adding individual utilities to obtain social utility. The first led to the development of the use of indifference curves in place of measurable utility, and the second led to the use of community preference function in place of total utility.

The indifference curve technique[1/] assumes only that the individual can compare various combinations of goods and services and state that he prefers one to another or is indifferent to the two. Confronted with the possible combinations, he could identify those to which he is indifferent. Figure 4 illustrates the sort of preference map which would represent this process for two goods. The lines I_1, I_2, and I_3 would be so-called indifference curves. He would be indifferent to all combinations of A and B along I_1, I_2, and I_3. He would prefer those of I_3 to I_2; and I_2 to I_1; thus I_3 is a higher indifference curve than I_2, and I_2 is higher than I_1. One indifference curve is higher than another in the sense that the person is better off on the higher curve, but nothing can be said about <u>how much</u> better off he is.

1/ For a fuller exposition of indifference curves, see Hicks, John R., <u>Value and Capital</u>, second edition. London: Oxford University Press, 1946.

To determine the choice of the individual between A and B, the relative price between the two, and the starting amounts of A and B must be given. Assuming that he starts with five units of A and none of B, and that the price is two units of B for one of A. This situation can be represented by a straight line--a so-called price line--between 5 A's and 10 B's. Starting with 5 units of A, the individual would exchange A for B until he reaches the highest possible indifference curve.

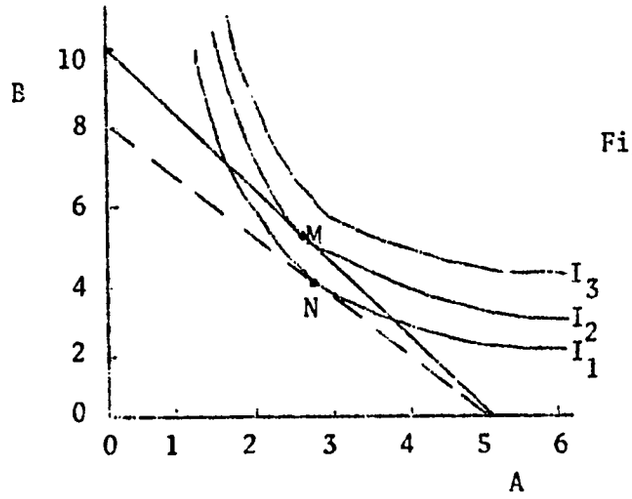

Figure 4

In the figure this would be I_2. If the price were 1.6 B's for 1 A, the dotted line would be the price line and he would go to point N.

Starting from the point with 5 units of A we could try a number of prices and trace out a series of points like M and N. For each price line the person would move to the point touching the highest indifference curve. This process would develop the whole schedule of quantities to be exchanged at different prices.

The general rule is simply that the individual would move along the price line until he reached a point where the price line is tangent to the highest indifference curve. The slope of the price line is the price of A in terms of B, and the slope of the indifference curve is the rate at which the individual can substitute B for A and still be equally satisfied (stay on the indifference curve). The latter is usually called the marginal rate of substitution. Thus the individual will move from his starting point along the price line until the price equals the marginal rate of substitution.

The same sort of analysis can be applied to any number of goods and services. Starting with the given money income, he buys goods and services until he has reached the point where the relative price between each pair is equal to the marginal rate of substitution between the two. Then he is at the highest welfare position he can achieve, although he cannot measure it relative to other possible combinations. If he has some good or service to sell at his starting point, he will sell it to the point where the price equals the marginal rate of substitution. When all transactions, either buying or selling, are accomplished, he will be at his highest welfare level.

We have now essentially brought the individual to the same point as that were he to have equalized all marginal utility--price ratios under the utility theory of value: He has reached his highest welfare position, given his starting income. But he has reached this point without having to be able to say what his marginal utility is for any good or service. It is

assumed only that he is able to establish his preferences between various combinations of goods and services that are possible for him to purchase. This assumption is far more reasonable than the one of measurable utility, and the conclusions which flow from it could be accepted with much greater confidence.

What conclusions may be drawn from the indifference curve analysis? Without detailing the argument, let us state the principal conclusion: Subject to certain assumptions, if individuals behave according to the mode of behavior outlined above, and if there are enough buyers and sellers in each market so that no one can individually influence prices, the resulting allocation of resources will be an optimum in the sense that no one could be better off without hurting someone else. In other words, each individual, once equilibrium has been reached, will be unable to make an exchange which would improve his welfare position without worsening that of someone else.

This conclusion was drawn by Pareto, the first person to make use of the indifference curve technique, and in his honor, the optimum allocation of resources which would exist under these conditions is called a Pareto optimum. It is also sometimes called an efficient allocation because all scarce resources are fully employed and no more of any good or service could be produced without cutting back the production of some other.

There are several important things to note about a Pareto optimum. First is that the prices which are established are competitive prices. Conversely allocating resources according to competitive prices, when other assumptions have been satisfied, will result in a Pareto optimum. Thus, we are back to the conclusion that competitive prices are the appropriate ones for project analysis because they allocate resources in an optimum way.

However--and these are the second and third points to note--it is an optimum only for a given distribution of income, and external economies are assumed not to exist. Thus, the reservations about competitive prices which were presented in sections 2 and 3, above, still apply.

Finally, the Pareto optimum says nothing at all about social or community welfare. It is thus an optimum only in the limited sense that each person is in a position where he cannot improve himself without hurting someone else. The state of community welfare cannot be determined because the Pareto optimum contains no means for combining the welfare of individuals. This shortcoming has led to the proposal of the so-called social welfare function.

The social welfare function[1/] has been proposed in a variety of forms. Some particularly simple forms were considered in the section on time preference. These all related welfare for the community to present and

---

1/ An excellent discussion of the social welfare function is contained in Samuelson, 1948, Chapter VIII.

future aggregate consumption in some way. They were based on the assumption of measurable utility, an assumption which we would now like to drop. The basic aim is to produce some sort of index of welfare for society which would be based on all factors which would go into individual and collective welfare. It would include the effects of non-economic factors which influence welfare as well as goods and services. The non-economic factors are, of course, assumed to be held constant for purposes of economic analysis. Were such an index available, the project planner would simply compare the effect on the index of various combinations of projects and choose the one that produced the greatest increase. A direct measure of utility that could be added together for individuals would be ideal, but there seems to be no way to measure utility. Hence, a community utility function does not appear to be a useful approach. The most that seems reasonable to assume is that methods could be devised for combining individual preference functions into some sort of community preference function. If a community preference function could be devised, it would serve the highly useful purpose of showing whether income redistribution would be beneficial or not. Figure 5 illustrates this argument.

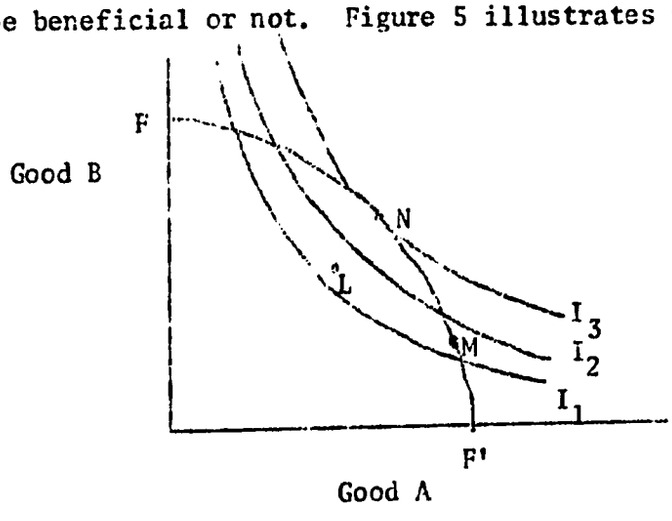

Figure 5

I_1, I_2, and I_3 are the social or community indifference curves in an economy producing goods A and B. The curved line FF' is the production possibility curve or production frontier for the economy. It shows that the maximum output of A could be for any given output of B, given the productive resources of the economy. The economy cannot produce above or to the right of FF' because of limited resources. Any output to the left and below FF', say point L, implies some unused resources that could be put to use and thereby increase the production of at least one good without cutting back the other, and possibly increasing the output of both. On the production frontier all (scarce) resources are utilized, and no more of one good could be produced without sacrificing the output of the other. Thus, it is the locus of efficient production points. It can be shown that this is equivalent to saying that each point on the frontier is a Pareto optimum associated with <u>some</u> (here unspecified) income distribution.[1/] Conversely, every income distribution has some unique point on the frontier to which it would lead. These conclusions are subject to the usual assumptions of no external economies, etc.

We may now draw some conclusions from Figure 5. Assume that the economy is producing at point M. Clearly under the conditions represented here, N is the preferable point. The planner must, therefore, devise

---

1/ Dorfman, R., Samuelson, P. A. and Solow, R. M., <u>Linear Programming and Economic Analysis</u>, New York; McGraw-Hill, 1958, pp. 408-15.

policies which will shift production from M to N. Central direction is one possible solution, but the problem could also be solved by redistributing income, perhaps by taxes and subsidies. If the appropriate distribution of income were known, and could be enforced, competitive markets and prices would bring the economy to point N. Without the redistribution it would remain at point M, an inferior welfare point.

Is a community preference function a reasonable concept.? It requires at least that some way for combining the individual preferences into a consistent set of general or social preferences be established. Unfortunately, it can be shown that such a consistent set of social preferences will usually not be possible. This result is due to Arrow.[1/] He has shown that where preferences only (no measurable utility) are used, and there are several individuals in society, it is impossible to construct a social preference function with satisfactory properties which will be valid for any consistent individual preferences. For example, the rule which gives equal voice for each individual may lead to a situation where the society prefers A to B, B to C, but C to A. This sort of inconsistency would make a useful social preference function an impossibility.

Under some conditions the sort of inconsistency which Arrow noted would not develop and a community preference function might be a reasonable concept. For example, if everyone's preferences were identical, or if they

---

1/ Arrow, K. J., Social Choice and Individual Values, second edition, New York: John Wiley and Sons, 1963.

were identical for over half of the population and majority rule established the social preferences. However, one need only observe a few friends to see that individual preferences are far from identical. Furthermore, in an underdeveloped economy, where the social structure is subject to rapid and often radical change, one would expect significant differences in individual preferences and probably substantial changes in preferences over time. Hence, a stable, consistent welfare function is highly unlikely. The conclusion seems unavoidable that analyses based on such a function are resting on rather weak foundations.

In the face of the criticisms given above, what can be done? At the theoretical level we must accept the fact that no real community preference function which reflects the preferences of the entire society can exist. Instead, someone, the planning authority or someone to whom the planner is responsible, must exercise a personal value judgment. If this person accepts the goal of maximum welfare for society, it would be hoped that the person making the value judgments will in some way reflect roughly the preferences of the public. Presumably in a democratic society, elected officials would do so, but even in these circumstances, there is no assurance that officials would give recognition to the preferences of even large segments of society.

In formal terms, what is being suggested here is that in place of the community preference function, that of the planner or the person to whom he is responsible be substituted. Presumably the preferences of one

person would be consistent and could approximately reflect community preferences. Tinbergen,[1/] Frisch,[2/] and others[3/] have suggested that development officials should establish weights for certain goals such as growth of national income, employment, income distribution, etc., and these be used to determine policy, including project evaluation. This procedure would in effect determine a crude sort of preference function. Where the planner is not ultimately responsible for policy, the weights would have to be established by interviewing responsible officials and establishing what to them are appropriate exchanges or tradeoffs between various goals. For example, how much redistribution of income is worth a given growth rate of GNP? Answers to such questions would establish the marginal rate of substitution between various goals and would permit crude approximations to a community preference function.[4/]

1/ Tinbergen, J., Economic Policy: Principles and Design. Amsterdam: North Holland Publishing Co., 1956, pp. 22-3. 101.

2/ Frisch, Ragnar, "An Interview Technique for Determining Linear (and Constant) Preference Coefficients," University of Pittsburgh Graduate School of Public and International Affairs, mimeographed, pp. 14, March 29, 1964.

3/ See, for example, United Nations Economic Commission for Asia and the Far East, Programming Techniques for Economic Development, Development Programming Techniques Series No. 1, Bangkok: 1960, pp. 35-7 (This pamphlet was written by a group of experts including Tinbergen); van Eijk, C. J., and Sandee, J., "Quantitative Determination of an Optimum Economic Policy," Econometrica, Vol. 27, No. 1 (January, 1959), pp. 1-13.

4/ Changes in government officials would result in different weights and a different community preference function. The differences might be quite substantial. The consequences of such shifts for prices are examined in Edwards, E., "Role of Prices in Development Planning Decisions," Center for Development Planning, National Planning Association, Washington, D. C., September, 1965 (mimeographed).

Experience in carrying out the sort of proposal made in the previous paragraph is limited, and its practical value is thus yet to be established. In particular practical methods have not been developed for translating information on trade-offs between goals into project planning decisions. Perhaps the use of accounting or shadow prices (discussed in the following section) could be interpreted as an effort along these lines, but this practice has related directly only to the goals of increased employment and increased output. Goals such as redistribution of income, increasing domestic ownership of industry, etc., have not been explicitly introduced into the project planning process in any analytically satisfactory manner and, in particular, their implications for evaluating project benefits and costs have not been worked out.[1/]

5. Finding Theoretically Correct Prices

At several previous points reference has been made to the conclusion that competitive prices or marginal cost prices should be used as prices for evaluating costs and benefits in projects. Some reservations about this conclusion have been presented, but assuming that it is correct, the problem of finding them must be solved. The obvious place to get prices is in free markets, but one is immediately confronted with the fact that very few markets are truly competitive, and the prices in most markets will

---

1/ This is perhaps a misleading statement. Projects and policies which are designed to achieve these goals have been undertaken in many countries. However, they are usually considered quite independent of other projects and without clear regard for other development goals.

deviate to a greater or lesser extent from their competitive levels. There are substantial elements of monopoly in many, if not most markets, and many are chronically in disequilibrium. Disequilibrium in this sense means that demand and supply remain indefinitely out of balance at the established price. Markets which commonly are in chronic and significant disequilibrium are those for labor, foreign exchange, and capital. Chronic unemployment is evidence of disequilibrium in the labor market; exchange controls reflect it in the foreign exchange market; and capital rationing, in various forms, reflects it in the capital market. Clearly, where markets do not meet competitive conditions, some sort of artificial prices which approximate competitive prices should be superior to market prices for project evaluation.[1/] The artificial prices which have been proposed for this purpose are usually called accounting or shadow prices.

1/ Do the deviations from competitive prices really matter at a practical level? For one writer who sees the problem as being relatively unimportant, see Harberger, Arnold C., "Using the Resources at Hand More Effectively," The American Economic Review, Vol. XLIX, No. 2 (May, 1959), pp. 134-46. Harberger examined the effect on growth in Chile of the price distortions brought on by inflation and concluded that they were relatively unimportant. Assuming that inflationary price distortions have effects similar to the sort discussed in the text above, one might conclude that the problem is not of sufficient magnitude to cause serious concern. Harberger's work was not, however, aimed directly at pricing for project analysis and, further, some of the statistical techniques which he was forced to use were quite shaky. Thus, while his results are suggestive, it is clear that much more empirical work needs to be done to be able to draw any firm conclusions on the problem.

Qayum[1/] and Chakravarty[2/] have provided the most extensive theoretical examination of shadow prices.[3/] Both provide the theoretical justification for their use. The justification briefly is that their use, at least for productive factors, leads to an efficient allocation of resources. Efficient is used here in the technical sense that all scarce resources are fully used and an increase in some output would require cutting back some other. They are essentially the same prices as would prevail if competitive markets existed and, with the usual assumptions, they would lead to an optimum resource allocation.

1/ Qayum, A., Theory and Policy of Accounting Prices. Amsterdam: North Holland Press, 1959.

2/ Chakravarty, S., "The Use of Shadow Prices in Programme Evaluation," in Rosenstein-Rodin, P. N. , (ed.), Capital Formation and Economic Development. Cambridge: M. I. T. Press, 1964, pp. 48-67.

3/ See also Chenery, H. B., and Kretschmer, K. S., "Resource Allocation for Economic Development," Econometrica, Vol. 24, No. 4 (October, 1956), pp. 365-99; Tinbergen, J., The Design of Development. Baltimore: Johns Hopkins Press, 1958; Chenery, H. B., and Clark, P. G., Interindustry Economics, New York: John Wiley and Sons, 1959; Papanek, G. F., and Qureshi, M. A., "The Use of Accounting Prices in Planning," in Organization, Planning and Programming for Economic Development, Vol. VIII of U. S. papers prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, Washington: Government Printing Office, n.d.; Dorfman, Samuelson, and Solow, 1958.

Shadow prices are a very attractive concept, but they suffer from certain problems that have limited their use. The first is the tremendously difficult job of estimating them. In effect the planner is being asked to solve the resource allocation problem for the economy! Conceptually, this could be done by means of a gigantic programming problem in which final output was to be maximized given the available factor resources. The program would be run and at the end the correct factor prices would come out as part of the solution. Those factors which are really scarce would all be used and have a price; those that were not scarce would not all be used and would have a zero price. But an examination of the programming problem reveals an anomaly. In essence, the solution to the problem consists of trying a combination of projects with a set of prices for the factors, choosing those that are profitable and determining which factors are in short supply and which have not been used up with this combination. Then prices are raised for those factors in short supply and reduced for those in surplus, and the process repeated. Each round should result in the factors becoming more nearly equal to their demand and the projects chosen, more nearly those of the efficient solution. After sufficient rounds, the combination of projects will be chosen which just uses up the scarce factors, and the factors which are not real restraints on the program, i.e., are surplus, will have zero prices. Thus, though the program solution does provide prices for the factors, it also makes the project selections. Hence, the shadow prices play no role in project selection! They only serve to show that a solution has been reached.

Chakravarty acknowledges the anomaly of the previous paragraph and suggests that what should be done is to devise certain approximations which do not require the solution to the full programming problem.[1/] This can be done at a relatively high level of aggregation for factors such as labor, foreign exchange and capital. The estimates derived in this fashion would then be utilized at the project analysis level.

Chakravarty notes another serious problem. The endowment of factors changes continually. Hence, what is needed is not a single shadow price for a factor but its path over time.[2/] The point is well taken, but he offers no suggestions for making this sort of estimate. Another situation in which the use of a changing shadow price is required is an economy where the real wage level is rising.[3/] Since development goals usually include, at least implicitly, an increasing wage for labor, this situation would seem to be universal. However, the inclusion of the effects on project costs of rising wages is practically unheard of.

At the practicing level, formal shadow prices have had little actual use in underdeveloped countries. Papanek and Qureshi[4/] have described a very simple use of shadow prices in Pakistan. The Pakistan experience is, in

---

1/ Chakravarty, 1964, pp. 51-52.

2/ Chakravarty, 1964, p. 51.

3/ This point was suggested by Eugene Grasberg.

4/ Papanek and Qureshi, n.d.

a way, typical of some other countries. They satisfied themselves with rough guesses at adjustments in the foreign exchange rate and the interest rate for capital, and they tried labor at two prices, the market wage and zero. No effort was made to obtain any sort of programming solution. Projects were then analyzed with the adjusted foreign exchange and interest rates and with the two wage rates, and the results were used as rough guides to the value of the projects.

The description of Pakistani experience in the Papanek-Qureshi paper, and the general dearth of literature on the application of shadow prices in underdeveloped countries would seem to suggest that at present shadow prices play a relatively small role in project planning in the under-developed countries. However, a point made in the Papanek-Qureshi paper suggests that at least in a rudimentary form, accounting prices are quite common. Papanek and Qureshi quite rightly point out that incorrect product prices, as well as factor prices, may lead to a misallocation of resources.[1/] They suggest that direct taxes and subsidies on goods cause variations in price unrelated to the real cost of production, and their effects should be eliminated. This is a perfectly logical adjustment, and it has been urged by most writers on project analysis[2/] who have been

---

1/ Papanek and Qureshi, n.d., pp. 102-3.

2/ See, for example, Bryce, M. D., 1960, chapter 2; United Nations, Economic Commission for Latin America, 1958, p. 203.

concerned with the valuation problem. This adjustment is a standard one wherever reasonably careful project analysis is undertaken. Similarly, we find that the adjustment of the cost of imports and the value of exports for overvaluation of foreign exchange is also recommended and practiced. Thus, we find that, like the man who was surprised that it was prose he had been speaking all his life, many underdeveloped countries have for years been using rough versions of accounting prices without calling them by this name!

Lest the significance of one aspect of the discussion in the preceding paragraphs be lost because it was hidden amongst accounting and shadow prices, let us return to the point. The market prices of both factors of production and of products may differ significantly from their "true" value to society. Where the causes for these deviations can be readily identified and their effects quantified, most writers on project evaluation would agree that appropriate adjustments should be made. Practically complete agreement would be obtained on the desirability of making adjustments for taxes and subsidies and foreign exchange overvaluation. Some dispute might arise over specific adjustments in capital costs and wage rates, but the idea would not generate real opposition. In general, the costs to be taken into account are those that represent a sacrifice of real resources, and these should be valued at their opportunity cost since the opportunity cost represents the real sacrifice of society. If the market value differs from the opportunity cost--because of taxes, subsidies, poorly functioning markets, etc.--corrections in the market value should be made. Similarly, if the market valuation of output is distorted--for the

same sort of reasons--corrections should be made. While such corrections may be suggested under a variety of names, all are designed to correct observed prices in roughly the same direction: to equal the prices that would prevail in a free market in equilibrium, not influenced by taxes or other factors extraneous to the exchange taking place.

This section will be closed on a note of uncertainty. The sort of prices which have been proposed for project evaluation are essentially competitive prices. The justification for the use of these prices is that they are the prices which would prevail in a Pareto optimum. However, to attain a Pareto optimum, all prices in the system must be competitive. What happens if one chooses projects using competitive price valuations when some prices in the economy are not competitive? Does using competitive prices for project evaluation under these conditions insure that the community will actually be better off, that it will be at a higher welfare level than without the projects? Unfortunately, the answer is no. Where monopolistic elements are present in the economy, where markets are chronically in disequilibrium, where external economies exist, etc., there is no assurance that the introduction of a competitive price at some point in the system will evoke responses which will move the economy toward a Pareto optimum. Hence, there is no assurance that community welfare will be greater; the increase in output from the projects may well be offset by a decrease elsewhere in the economy. This problem has been discussed as

the theory of the second best.[1/] While the theory of the second best has not been applied explicitly to development problems, it is apparent that the conclusions which have been reached on the subject apply equally well to underdeveloped, as well as developed, countries.

Most writers on project planning apparently prefer to ignore the problem of the second best. The uncertainty which it creates seems to have been met with the attitude that while the theory is doubtless correct, it is a fair presumption that in any given case, competitive or marginal cost prices will result in an improvement in welfare. McKean[2/] explicitly argues in this fashion and most others who have written on valuation for project planning would probably agree. McKean also offers the opinion that, "It is surely possible in many problems to distinguish better from worse courses of action."[3/] He does not follow up the point, but it seems reasonable to hope that this would often be the case. An

---

1/ A full exposition of the theory of the second best is contained in Lipsey, R. G. and Lancaster, R. K., "The General Theory of the Second Best," The Review of Economic Studies, Vol. XXIV, No. 63 (1956-57). See also Fishlow, A., and David, P. "Optimal Resource Allocation in an Imperfect Market Setting," The Journal of Political Economy, Vol. LXIX, No. 6, (December, 1961); Mishan, E. J., "Second Thoughts on Second Best," Oxford Economic Papers, Vol. 14, No. 3 (October, 1962); McMannus, M., "Comments on the General Theory of Second Best," The Review of Economic Studies, Vol, XXVI, No. 3, (June, 1959).

2/ McKean, Roland N., Efficiency in Government Through Systems Analysis. New York: John Wiley and Sons, 1958, pp. 130-1.

3/ McKean, 1958, fn. pp. 131.

example would be building a bridge for autos into a large city like New York. It is well recognized today--if it was not some years ago--that marginal cost pricing for crossing the bridge will create congestion in the central city that is a high cost to society. Some other solution to the need for crossing the river may be far more desirable for society.

6. Failure of Marginally Determined Prices to Reflect Total Benefits

We turn now to a problem that is of great importance in project planning but about which there is at present only partial agreement. The problem concerns the fact that competitive or marginal cost prices give a satisfactory valuation for marginal benefits but not total benefits. To illustrate the problem, we will make use of the concept of consumers' surplus. Consumers' surplus has rather shaky theoretical foundations, but it is quite satisfactory for indicating the nature of the problem.

In discussing consumers' surplus, we will be following the argument pretty much as presented in Marshall.[1/] Let us consider the demand and supply curves of good A, as shown in Figure 6. As drawn here, the price would be $2.50 and 3,000 units would be sold. However, as shown in the discussion on utility analysis, the $2.50 measures the value only of the

---

1/ Marshall, 1920. Another excellent account is given in Hirschleifer, J., DeHaven, J. C., and Milliman, J. W., Water Supply, Economics, Technology, and Policy. Chicago: University of Chicago Press, 1960.

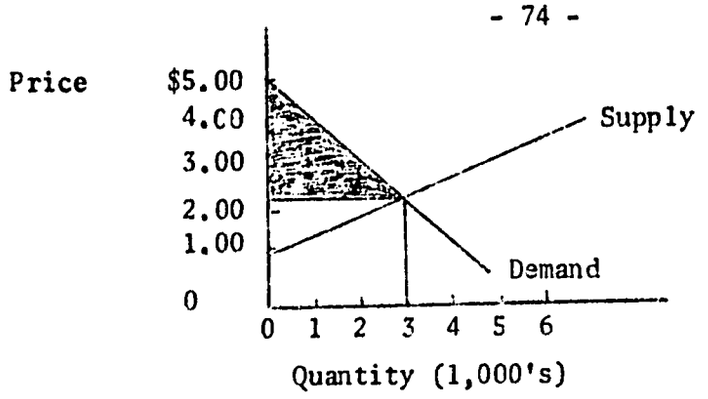

Figure 6

marginal or last unit sold. The intra-marginal units are worth more to the purchasers. In fact, if put on an all-or-none basis, the first 3,000 units would be worth the sum equal to the area beneath the demand curve out to 3,000 units; i.e., $11,250. (If the idea of measurable utility were accepted, this sum would measure the total utility of 3,000 units of A; see the earlier discussion on this point.) Yet the purchasers pay an aggregate equal to the area up to the price; i.e., $7,500. Evidently, the purchasers have a value for their own uses which in aggregate is considerably in excess of the market value. This excess was called consumers' surplus by Marshall. It would be equal to the shaded area above the price line to the demand curve. In this case it would be $3,750. Assuming that the demand curve represents society's valuation of good A, it is clear that the market price gives an exchange value considerably less than the use or social value of 3,000 units of A. If one wished to have a unit price which reflected the use or social value, it would be $\frac{11,250}{3,000}$ = $3.75 rather than the exchange or market price of $2.50. (In terms of the earlier utility analysis, this would be a measure of <u>average</u> utility as opposed to the market price which would be a measure of <u>marginal</u> utility.)

The same sort of analysis could be applied to the supply curve. The supply curve is the marginal cost curve of suppliers, and it can be treated in a symmetrical fashion to the demand curve. Suppliers actually receive $7,500 or $2.50 per unit, but their aggregate costs are equal to only the area beneath the supply curve, $5,250 or $1.75 per unit. The suppliers, therefore, receive a surplus of $2,250. It is equal to the area from the supply curve to the price line. Marshall named this excess producers' surplus. Assuming that the supply curve of good A represents society's valuation of resources going into the production of A, i.e., their social opportunity cost, the average cost is $1.75 per unit as against the marginal cost of $2.50. The triangle between the y axis, the supply curve, and the demand curve represents the net social utility; i.e., the net gain to society from the exchange. When there is a market, the shaded part represents the utility that goes to consumers and the unshaded part represents the utility that goes to producers. The market structure establishes the division of welfare between the two groups. (When the market is in Marshallian long-run equilibrium, the producers' surplus provides just the economy-wide rate of return on investment.)

What has all this to do with project evaluation? To understand the significance of the difference between these various prices, let us return to the original formulation of the project planner's problem. It was assumed that he had certain resources under his control and he was to choose the combination of projects which would result in the maximum contribution to the community's welfare. If some sort of what might be

called welfare prices could be established, the various projects could be compared at their values using these prices, and the combination with the highest aggregate value among those that could be executed with the available resources would be chosen. The analysis above shows clearly that marginally determined prices are not appropriate for this purpose. Such prices, in general, though not necessarily in all individual cases, understate the social or use value of a given output. They may also overstate social or opportunity use value of the inputs for that production, although declining costs over relevant ranges of production are common enough to make this conclusion less general than the corresponding one for outputs.

Faced with this problem, what can the project analyst do? The answer to this question depends on certain characteristics of the project planning system and its position in the economy. Under some circumstances, it may still be appropriate to use marginally determined prices, and under others some adjustments should be made.

The first case is where there are no limits on the funds available to the planner and all projects are completely divisible; i.e., all projects can be adjusted at the margin and no "lumpiness" exists. Under these conditions the project planner should use marginal cost prices and behave exactly like the private competitor, except to make allowances for external

economies.[1/] If a project looks profitable with these prices (including an appropriate opportunity cost for capital), he should undertake it. Under this rule prices do not act as indicators of welfare values but only as pointers in allocating resources. The project planner does not need to know true welfare values because he knows that in picking projects which are profitable, he is picking ones which will contribute to welfare. He chooses the size so as to have no profit on the marginal increment of the project. By following the rule, the project planner is simply helping the economy to a Pareto optimum.

The second case would be where a given project is small enough not to affect either input or output prices. In this case, the project is itself marginal to the economy and the marginal and average values would be the same. Hence, marginal cost or competitive pricing would be appropriate. No question of divisibility arises because the project is small enough relative to the economy to be considered as a marginal increment to both output and factor demand. Under these conditions, some sort of limitation on available funds may exist, and a selection criterion between profitable projects would then have to be employed. The problem is that projects cannot be undertaken to the point where profitable ones are exhausted and, therefore, some sort of choice must be made between them. Since, however, the marginal cost prices are representative of social valuations, no problem arises as far as pricing inputs and outputs is concerned.

1/ This is essentially the rule which Abba Lerner advocated for the entire economy, and projects would be just one part of the economy in this context. See Lerner, 1944.

The third and fourth cases may be considered together. They consist of projects which significantly affect the prices of either outputs or factor inputs. Such projects will occur wherever projects are essentially not divisible, i.e., they are "lumpy," or the appropriate scale of operation is large relative to either the market for output or some factor input. Since the consequences for project evaluation are the same, regardless of whether the effects occur because of lumpiness or simply scale, these two cases may be considered together.

To demonstrate the nature of the problem, two projects of the same size will be considered, with a choice between the two being required. They consist of investments in industry A or B, and the effect is to increase capacity significantly in each. The analysis will be made in terms of consumers' surplus initially, although this technique has some shortcomings which will be noted shortly.

The situation is illustrated in Figure 8. The shift in the supply curves represents the effect of increasing capacity in each. Initial prices would be $3.00 for A, and $50 for B. At initial market prices, the 2,000 units of A produced and sold would be worth $6,000, and the 200 units of B would be worth $10,000. If project A were undertaken, the price would fall to $2.50 and the 2,500 units purchased would be worth $6,250. If project B were undertaken, the price of B would fall to $40, and the 240 purchased would be worth $9,600.

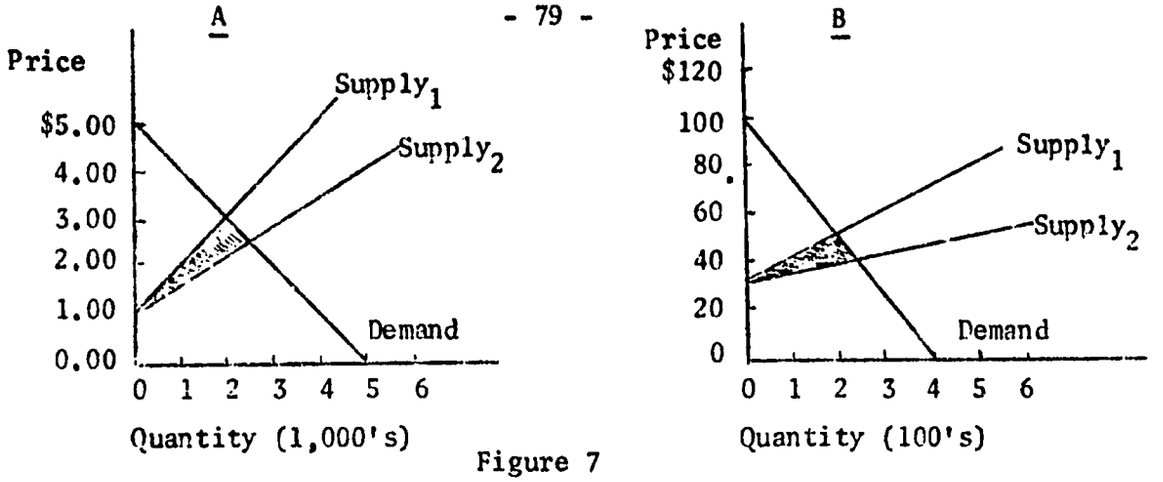

Figure 7

Under the conditions given above, if there were no funds limitations, both projects should be undertaken because they would both be advantageous with present resources. But here we are faced with a choice, perhaps because of a budget limit. From society's point of view which should be chosen? Using the marginal valuations determined by the intersection of the supply and demand curves, both projects would look the same: In each case cost and revenue are equal. But these are marginal valuations, and the value to society might be quite different. The change in consumers' and producers' surpluses, i.e., the change in net social utility, can be used here as a measure of the increase in social value from the investment. This change would be represented by the shaded areas. It would be an increase of $1,000 for project A and $1,400 for project B. (For project A, consumers' surplus would increase by $1,125 and producers' surplus would fall by $125, giving the net increase of $1,000. For project B, consumers' surplus would increase by $2,200 and producers' surplus would fall by $800, giving the net increase of $1,400.) B would thus be superior.

What has been done here is in effect to compare these two projects on the basis of their social values rather than their market or marginal values. The comparison has been made only by calculating the net change in the sum of consumers' and producers' surpluses for the two projects. Since the two projects cost the same by assumption, the choice can be made on the basis of which one provides the greater increase. Where different scales are involved, a somewhat different criterion would be needed, but the valuation problem is the same.

From the illustration it would appear that where choices between projects must be made under the third and fourth set of conditions, the way to proceed would be to estimate the changes in the two surpluses and adjust the market valuations of benefits and costs accordingly.[1/] This procedure, however, would not in general be legitimate, quite apart from the problem of estimating the supply and demand curves. The basic problem of marginally determined prices is well illustrated with the concepts of consumer and producer surpluses, but, as Marshall was quick to admit,[2/]

1/ The problem considered here is sometimes discussed as an index number problem. The increase in output is of some value to the customers, but what value? If beginning prices (pre-project) are used, too high a valuation will result. If ending prices (post-project) are used, too low a valuation will result. The correct price is some average of the two prices. In the example in the text the correct price is a simple average; were there curvature in the demand curve, unequal weights would be required.

2/ Marshall, 1920, Chapter III, Book III.

these surpluses do not in general accurately measure the value to society of the goods in question. Part of the problem originates in the step linking the dollar calculations to utility. Even if one accepts the notion of a measurable utility, if the calculated surpluses are to be interpreted as being a measure of total utility, it must be assumed that the marginal utility of money is constant.[1/] For small projects this might be a legitimate assumption, but certainly not for one which radically changes the economic structure of a community.

More important than the assumption of constant marginal utility of money are the effects of interdependencies between various economic activities. With changes in one market, there will be ripples extending throughout the economy which will create or destroy surpluses not reflected in the demand and supply curves of the immediate market. These consequences will depend on whether the product is competitive or complimentary to other goods and services, on technology, and similar factors. The ordinary Marshallian demand and supply curves for a commodity are defined with all other things remaining the same. What we are saying is that, in general, they will <u>not</u> remain the same. The situation may be illustrated by means of the production possibility curve and a set of community indifference curves. (The community indifference curves are presented here only for discussion purposes and not with the assumption that they have operational meaning.) Figure 8 presents the situation where goods A and B are being produced in the combination shown at point one. If project A is undertaken,

---

1/ See Hicks, J. R., 1941.

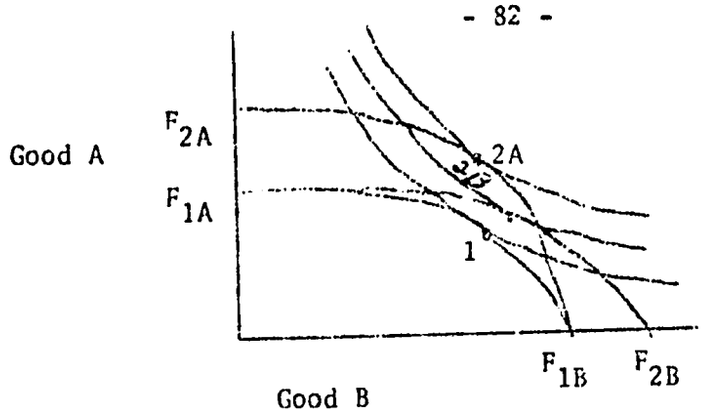

Figure 8

the production frontier will move from $F_{1A}F_{1B}$ to $F_{2A}F_{1B}$; if project B is undertaken, the frontier will move to $F_{1A}F_{2B}$. From the diagram it is clear that project A which brings the economy to point 2A is preferred to project B which brings the economy to point 2B. The community indifference curves have been drawn to be consistent with the demand curves of A and B in the surplus analysis above, yet we find that A would be chosen rather than B, using this analysis. The explanation lies in the simultaneous adjustment taking place in the factor markets and the two product markets.

Marshall, in the context of his Principles of Economics, felt it was not worth struggling to state just how these inter-relationships would affect the surplus measurement,[1/] but the consensus now seems to be that for project evaluation, at least the most important effects outside the immediate market should be taken into account.[2/] There is certainly no agreement, however, as to how far the process should be carried or what is legitimate

---

1/ Marshall, 1920, fn. p. 131.

2/ See Foster, C. D., "Surplus Criteria for Investment," Bulletin of the Oxford Institute of Statistics, Vol. 22, No. 4.

to count. McKean[1/] and Hirschliefer-et al[2/] warn against the sort of double counting and omissions which are all too easy to make when trying to trace through the economy the effects of a given project. They seem to agree that the primary benefits (what have been called here the change in consumers' surplus) and the effects of technological spillovers (what have been called here technological external economics and diseconomies) should be included. However, purely pecuniary spillovers, which they define as the increases or decreases in capital values or incomes solely because of the competitive or complimentary effect of the facilities constructed, should not be included. These, they argue, do not have consequences for the efficient allocation of resources, but admittedly they do affect income distribution. This conclusion seems reasonable for developed countries, but for underdeveloped countries, it is entirely possible that a given project, say a road, will result in opening a region for production that would not otherwise have taken place. Is the value of this production, above the transportation cost, in some way a benefit of the road project? It would appear to be so, but its measurement as far as the road project is concerned is not at all clear. A further complication would be that other resources may be used in addition to those devoted to the road. Thus the project should be considered the road plus associated activities.

1/ McKean, 1958, Chapter 9.

2/ Hirschleifer, DeHaven and Milliman, 1960, Chapter VI.

Bos and Koyck[1/] have illustrated the problem of the previous paragraph with a model containing three producing centers. They examine the effect on national product of a road built between the agricultural center and the two industrial centers. They show that the overall effect is considerably greater than the immediate saving in transportation cost regardless of whether pre-or post-project transport prices are used to value the saving. However, their model is so simple by comparison to a real problem that they do not provide much guidance for measuring benefits in such cases.

The measurement of benefits and costs not directly valued in a project, whether they be called consumers' surplus, secondary benefits, spillovers, social surplus, or whatever, is an extremely difficult problem. These difficulties are well illustrated by the study by Foster and Beesley of the Victoria Line.[2/] This line was to be part of the London Transport Underground. They made estimates of the value of time savings, fare and cost savings, and improvement in comfort and convenience for users of the new line and users of other transport systems that would be affected by changes in the volume of traffic. Some of the benefits were not actually calculated, but the ingenuity and comprehensiveness of their effort were indeed impressive.

1/ Bos, H. C., and Koyck, L. M., "The Appraisal of Road Construction Projects: A Practical Example," The Review of Economics and Statistics, Vol. XLIII, No. 1 (February, 1961) pp. 13-20.

2/ Foster, C. D., and Beesley, M. E., "Estimating the Social Benefit of Constructing an Underground Railway in London," Journal of the Royal Statistical Society, Series A (General), Vol. 126, Part 1, (1963), pp. 46-78.

One set of benefits which Foster and Beesley did not include were those of increased production which the line might stimulate in one fashion or another. In this particular case, such benefits probably should not be included. However, in an underdeveloped country, the construction of a rail line into an area which previously had only some high cost form of transportation may lead to the stimulation of substantial increases in production. Sticking to the sort of benefits which Foster and Beesley considered would lead to the omission of this increase (except for the part reflected in transport values). Yet in the undeveloped area, the production would not have taken place without the railroad, and the resources which would have gone into this production would not have been used as productively elsewhere. Is this not then a benefit of the railroad construction?

The measurement of secondary benefits, spillovers, social surpluses, or whatever they may be called, is an extremely difficult problem. At the present time, there is still considerable disagreement over just what they are and how they should be measured. The type noted in the previous paragraph is one in particular about which there is disagreement.

7. Finding Prices for Non-marketed Outputs

One of the most vexing questions concerning valuation for purposes of project analysis is how to value outputs for which no market prices can be established. Examples are education, health and research projects. In general, most of the projects which we have called class two, three, and four projects would have this characteristic. The same problem can occur for inputs which do not have market prices, but this problem seems to be much less common and has little practical significance.

Until a dozen or so years ago, this situation was accepted as being inevitable. For national income accounting purposes, such activities have been conventionally valued at cost. This treatment is obviously of no use in project evaluation. Lacking a satisfactory alternative, for project evaluation such non-marketed outputs were usually left in physical units. Educational projects would be measured in such terms as the number of students finishing a particular grade, the number of classrooms constructed, etc.; health projects would be measured in the number of patients visiting a clinic, the number of people in an area in which malaria had been eradicated, etc.; and research projects would be measured in such terms as man-hours devoted to a particular problem. As recently as 1959, the U.N. published a pamphlet[1/] recommending this approach. Some sort of

---

1/ Hayes, S. P., Jr., Measuring the Results of Development Projects: a Manual for the Use of Field Workers. New York, UNESCO, 1959.

standards could be worked out by comparison with similar efforts in the same country or abroad, but these would still be in terms of the diverse sort of units noted above.

The obvious difficulty with the sort of approach described above is that it provides no basis for comparison, or selection, among projects which are not similar. Education projects cannot be compared with industrial, or health, or any other type of project, in fact, not even with many other education projects if their outputs are not measured in the same units. This situation seems likely to continue more-or-less indefinitely in the future. There have been, however, some efforts to put this type of project on the same footing as those projects with an output which can readily be valued, and these efforts offer some hope of improving the situation. Two approaches have been proposed. The first is the income-differential method and the second is the cost-of-alternative-projects method.

Both of these approaches are well illustrated in the report[1/] of a recent conference on measuring benefits of government investments. The papers presented at this conference covered projects in a number of fields ranging from education and health to defense. The quality of these papers is very high, and the reader is referred to this report for the application of these methods to specific projects.

1/ Dorfman, Robert, ed., Measuring Benefits of Government Investments, Washington: Brookings Institution, 1965.

The income differential method recognizes that projects of the sort considered here are investments in a broad sense. As investments, they create value in the form of later output which in theory could be measured. Such an investment has often been called investment in human capital because it takes the form of improving human skills, improving human health, or increasing knowledge.[1/] The method is based on the fact that the value of output equals the sum of factor payments plus direct taxes. From this relationship it can be seen that the output which an educational project produces in the future could be measured by the increase in income which labor will receive as a result of the educational project. Similarly, the output contribution of a health project could be measured by the increased income received by those whose health is improved--the increase in income received for fewer days absent from the job or for better work while on the job. Thus, if the increase in future income to the beneficiaries of the project were measured, the contribution to future production would be found.

The measurement problems involved in the estimation of incomes accruing to labor from education and health projects are very great. The increment in income which an individual receives because of a particular educational experience is never separated and easily identifiable from that which he would have received otherwise. Furthermore, part of education

---

1/ The body of literature on the subject of human capital is quite large and growing rapidly. For a good overview of the subject see Schultz, T. W., "Investment in Human Capital," The American Economic Review, Vol. LI, No. 2 (March, 1961).

is a form of current consumption. Hence, the cost is not entirely investment. At the present time, not enough is known about estimating income differentials and separating the consumption part from the investment part to use the income differential method for project planning. Bowman[1/] concludes that work on this technique for use in education should continue but that past methods will have to be used for the present. In health, the income differential method has also been proposed,[2/] but much the same uncertain situation prevails in this field. Enough is known about the subject to state positively that returns from education and health expenditures are high, but measuring them exactly and identifying them with specific expenditures is not at present possible. Hence, for the present, the sort of project analysis which does not attempt to measure benefits for comparison with other projects seems likely to be continued.

Research and development is another field where outputs are difficult to measure and value. The benefits of such expenditures have received attention in the developed countries, but they are of rather speculative quality. The best example of this sort of work is Economic Benefits from Oceanographic Research of the National Academy of Sciences.[3/] This pamphlet illustrates the calculation of benefits and costs pushed to their practical limits, and perhaps somewhat beyond.

1/ Bowman, Mary Jean, "Perspectives on Education and Development," International Development Review, Vol. VI, No. 3 (September, 1964).

2/ See, for example, Kaser, M. C., "Health Planning as a Part of the National Development Plan," Working Document WHO/PHA4/W.P.7. Geneva: World Health Organization, 1960.

3/ Committee on Oceanography, National Academy of Sciences - National Research Council, Economic Benefits from Oceanographic Research. Washington, D. C., 1964.

The cost-of-alternative-projects method approaches the problem of measuring benefits from a very different viewpoint than the income-differential method. Basically, it attempts to use the cost of an alternative project, which provides the same benefits, as a substitute for, or at least a limit to, the benefits from a given project.

Steiner[1/] has made a systematic analysis of this proposition. He notes that there is a good deal of fuzzy folklore to this effect. He concludes that alternative costs really do not measure benefits except in very limited cases. In some circumstances, they may permit the measurement of benefit increments from parts of projects but not total benefits. His final summing up is that alternative costs will often permit decisions on whether projects should be carried out or not, but they will not generally measure benefits. Their use in project analysis may significantly reduce the number of projects in which precise benefit measurement is necessary and, thus, may be very useful. However, this is basically project selection, not benefit measurement. Thus, alternative costs seem destined to play no important role in measuring benefits.

There are, of course, many types of government projects for which outputs are not priced, and they will all provide problems of evaluating benefits similar to the examples discussed above. These range from public

---

1/ Steiner, Peter O., "The Role of Alternative Cost in Project Design and Selection," The Quarterly Journal of Economics, Vol. LXXIX, No. 3, (August, 1965), pp. 417-30.

parks and other activities designed to improve the welfare of individual consumers to activities which may increase the productiveness of the producing part of the economy. Ingenuity may provide methods for making rough estimates of the monetary value to society of such projects. The pamphlet on research in the field of oceanography is an example. Unfortunately, the difficulties in measuring benefits to society of various outputs are not uniform across all types of projects. It is generally agreed that the problems of measuring the benefits of an industrial project, for example, are relatively easy to solve. By comparison the estimation of benefits from an education project or a health project is exceedingly uncertain. In the cases where estimation of benefits is uncertain, it is not clear even in which direction the measurement process may be biased.

A further difficulty is that the measurable part of the project's benefits may be quite small. This was a common theme that ran through the papers of the conference on measuring government benefits.[1/] Dorfman, in his introduction to the report of this conference, compared the situation to a rabbit and horse meat stew: The rabbit may be very good, but if it is only a small part of the ingredients, the horse will dominate the flavor of the stew. Similarly, if the benefits can be measured for only a small part of a project, selection criteria which depend on benefit measurement cannot be used.

1/ Dorfman, ed., 1965.

The difficulties and uncertainties of measuring benefits in so many fields has led to the general practice of comparing projects only within a given sector where the measurement problems are similar. Thus, education projects are compared with other education projects, health projects with other health projects, and so on. At the present time, it is generally accepted as being impossible to make any direct comparisons of the benefits accruing from projects in very different sectors. This situation means that the ideal system of project analysis where various combinations of all sorts of projects are compared to each other is impossible to accomplish. Hence, any overall allocation of resources cannot be made in an optimum sense. Instead, whatever optimum allocation is made must be only within sectors, and the choice of division between sectors must be made on other grounds. Furthermore, within sectors such as education and health, the aim of approaching a sectoral optimum seems pointless.

On this pessimistic note, we turn to the third step in the ideal project planning system, selecting projects for execution.

V. STEP III: SELECTION OF PROJECTS

The third step in the project planning scheme is the selection of projects to be carried out. This step is carried out once the benefits and costs have been appropriately valued. The problem of valuation is not always independent of the selection procedure, but it will be assumed that they are independent until this complication is explicitly introduced.

A. INTRODUCTION

Selection procedures have provided by far the most controversy in the literature of project planning.[1/] Unfortunately there is no single selection criterion which is appropriate under all circumstances. Careful examination of the problem shows that the appropriate criterion will depend on a number of factors such as whether there are resources to allocate in addition to capital, what sort of economic system exists, whether comparisons are to be made with other projects, and even the level of sophistication of those who must work on project analysis. When institutional arrangements and other practical considerations enter the picture, it becomes clear that there is no single selection method which is perfect for all situations.

1/ Some surveys of the selection problem are: (1) Eckstein, 1961; (2) Christenson, Charles, "Capital Budgeting and Long-Range Planning" in Hertz, D. B. and Eddison, Roger T. (editors), Progress in Operations Research Volume II, New York: John Wiley and Sons, 1964, Chap. 6; (3) Dryden, Myles M., "Capital Budgeting: Treatment of Uncertainty and Investment Criteria," The Scottish Journal of Political Economy, Vol. XI, No. 3 (November, 1964), p. 235-59.

Thus, much of the controversy on this subject is resolved when it is discovered that various circumstances surrounding the selection process must be specified before the choice of a selection criterion can be made. This introductory section will examine the most significant matters in this regard.

Three topics will be examined here. They are as follows: (1) The general economic framework of project selection. It is shown that the selection problem is usually one of allocating capital. However, when other resources such as labor are allocated improperly by the economy, their inclusion may require modification of selection procedures. (2) The effect of differing economic systems. It is shown how competitive, totally planned, corporation dominated, and open, less developed economies will differ in decisions about capital allocation. (3) The three basic types of project selection decisions. These are shown to be decisions on whether or not to go ahead with a given project, the choice of a particular project from several designed to accomplish the same purpose, and the choice of a set of projects within some sort of budget or capital limitation.

The three topics listed above provide a background for the systematic discussion of specific selection criteria which follows in section B. A few conclusions about appropriate selection criteria are included in the introductory section, but the full analyses of individual criteria are in section B.

1. The General Economic Framework of Project Selection

Basically, all selection criteria are methods of comparing different ways of allocating resources. Earlier discussion has emphasized that the usual desired objective of public policy is increased national output. Thus, one is led to ask, "What is the best way to allocate resources to maximize output?" In fact, however, in most project selection problems it is capital that we are allocating, and not all resources. This will be shown to be the correct approach in many circumstances. Fortunately, when it is necessary to allocate other resources, such as labor, the approach presented here can be generalized to include factors other than capital. It will be shown that some of the differences which have arisen over appropriate selection criteria arise because of different viewpoints on just what resources are to be allocated.

Why is it that with increases in national output as the basic objective, project selection should usually be considered as a problem of maximizing the earnings from capital? The answer is simply that what one is trying to do is to maximize the surplus above factor payments, when factors are valued at their correct opportunity cost, for by so doing national product will be greatest. This surplus is the earnings to capital; hence, maximizing capital earnings will maximize national product also. If labor, or any other resource for that matter, is not fully utilized, it will be valued at zero opportunity cost; all national product would then be properly imputed to capital and maximizing profits would be equivalent to maximizing national income.

Of course, as was emphasized in Part IV, from a strict viewpoint one should investigate the change in utility that arises from the project. If the utility function is a monotonic function of a single variable, then to maximize utility, clearly one maximizes that variable. If there is more than one variable in the utility function, the problem is not clear cut. In the one variable case we can well ask what is this variable. The obvious answer is consumption. This, however, is questionable for two reasons, both practical and theoretical. First, if we use consumption, all consumption induced by the project should be included. This is a very broad requirement, for it includes not only consumption arising directly from the project but also consumption arising from subsequent investments financed by saving from the project and any further consumption which may arise in such a chain fashion.[1/] Thus, the benefits from any project would have an infinite stream. If the time preference discount rate used on such a benefit stream was close to the growth rate of the consumption induced by the project, the contribution from the future indirect consumption could be quite large. It seems impractical to think such an estimate could be made. If we cut off the consumption stream at some point in time (the lifetime of the project, for example), then the terminal stock of capital is also a relevant variable in the utility function (or preference structure). Since

---

1/ This point is discussed in Eckstein, Otto, 1957; also, in Feldstein, M. S., "Net Social Benefit Calculations and the Public Investment Decision," Oxford Economic Papers, Vol. 16, No. 1 (March, 1964), pp. 114-131.

the terminal stock of capital is determined by output and consumption, it may be satisfactory to consider the level of output as the proper measure.

Second, it is the returns to capital that are relevant in judging investment projects, as has been explained above. Consumption which arises from payments to labor should not affect the project selection process, since these should be the same for different combinations of projects. To put it another way, the disposal of future income is not relevant to the selection of projects at this time. This view has been disputed, and we shall take it up again later.

Selection criteria are all rules which purport to study the equilibrium conditions of some capital market. This capital market may be the economy as a whole, or it may be a corporation investing in a large number of projects, or it may be a single entrepreneur. In each case, however, we must have clearly in mind the supply and demand relationships in the particular capital market. Failure to differentiate clearly between supply and demand, or failure to recognize the equilibrium nature of selection criteria, is at the base of considerable confusion in the literature. The purpose of this section is to review some simple alternative ways to determine what may be assumed to be the equilibrium condition in the market. To this end we have drawn three figures. The first figure (Figure 9) shows the traditional supply and demand equilibrium in a capital market.

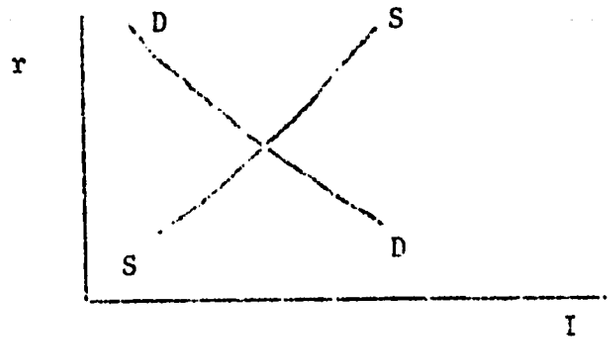

Figure 9

The demand curve DD slopes downward to the right, illustrating the fact that as the interest rate, r (i.e., the cost of capital), falls, the amount of investment, I, will rise. In the same way, the supply curve SS rises to the right, showing that as the interest rate increases, saving will increase also. In the usual fashion, equilibrium in the investment market comes where the supply and demand curves intersect. This intersection point determines the equilibrium rate of return and the amount of investment. For some problems certain parts of the diagram will be known and will give the equilibrium interest rate, or the equilibrium investment level, whichever is missing. The situation in which the interest rate and the demand schedule for capital are given is sketched in Figure 10, and that where the equilibrium supply of capital and the demand schedule for capital are given is sketched in Figure 11.

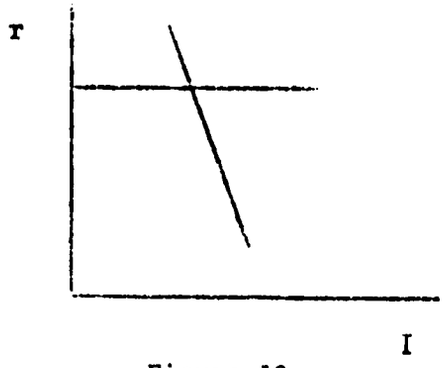

Figure 10

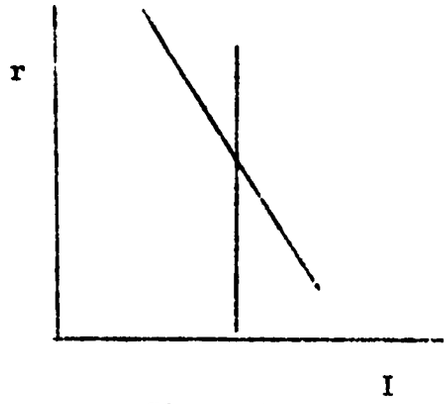

Figure 11

It is not, in general, possible to have given the equilibrium interest rate and the equilibrium supply of capital and expect this point to be on the demand schedule. As long as these three elements are determined independently of each other, it would only be accidental for the specified interest rate-capital supply combination to be a point on the capital demand schedule. Consistency of the three elements given would only be accidental, yet some selection criteria by implication assume all three as given. Where this consistency is lacking, selection is performed under conditions of disequilibrium, rather than equilibrium, and misallocation can result.

Note that in a growing economy, the amount of investment is determined by the level of saving, which may be affected by the interest rate (Figure 9), or may be independent of the interest rate (Figure 11). In either case the interest rate is a derivative concept. On the other hand, in the Keynesian analysis where the growth consequences of investment are ignored, the spirit of the argument is that the money market determines the interest rate and the level of investment is then determined by the demand for investment curve (Figure 10). In working on a project selection problem, it is important to keep the sort of mechanism by which the capital market reaches equilibrium in mind.

We next want to expand this analysis to study some more complex cases. First, we study the problem of allocating capital and labor among projects. The demand for investment goods can now be formulated as being dependent on the wage rate and the interest rate. Holding the wage rate constant we can determine the demand for investment curve; for each different wage rate we will have a different demand for investment curve. This is sketched in Figure 12.

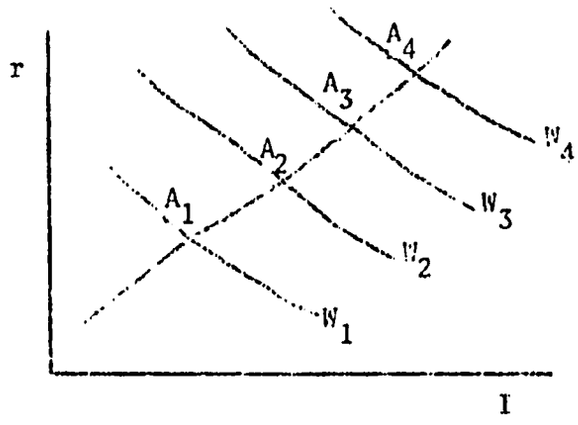

Figure 12

The higher the wage, the less investment there should be for a given rate of return. In the notation of Figure 12, $W_1 > W_2 > W_3 > W_4$, etc. We can now impose a supply curve either in the form of a given interest rate, a given supply of investable funds, or a supply curve which relates the supply of investable funds to the interest rate. In each case, we can determine the intersections of the demand curves with the supply curve, thereby relating the wage rate to the amount of investment. In Figure 14 the equilibrium points (A_1, A_2, A_3, A_4) for Figure 13 are plotted.

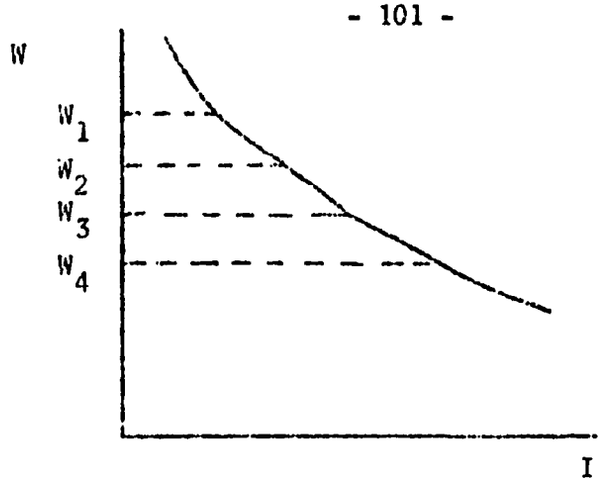

Figure 13

Next we note that each point on the demand curves of Figure 13 represents a group of projects and, therefore, represents a given labor requirement to work on the new project. For each of the equilibrium points, A_1, A_2, A_3, A_4, of Figure 12, we can determine the labor requirements. Figure 13 can be redrawn then to relate the wage rate to the labor demanded. This gives DD in Figure 14.

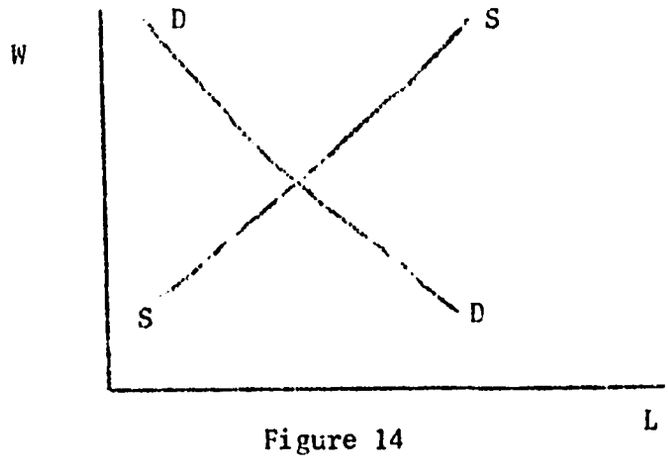

Figure 14

The DD line of Figure 14 represents the demand for labor (for new projects) when the capital market is in equilibrium. Each point on DD represents a different collection of projects. A supply of labor curve has been added to Figure 15 to show how equilibrium in the labor market is achieved. This supply curve represents the amount of labor available to the new projects.

If the amount of labor being supplied to new projects is small relative to total employment in the economy, then we would expect the wage rate to be a horizontal line at the level of the wage rate for the entire economy. In this event, we would return to Figure 12, noting that there is only one investment demand curve, and the situation reverts to the prior case. This is the assumption usually made in project selection. This wage rate may be zero if the opportunity cost of labor is zero or it may be positive; what is relevant is that it is constant over different groups of projects. Returning to the argument of the first few pages of Part V, it should be noted that the addition to national income from the investment is given by the area OABC in Figure 15.

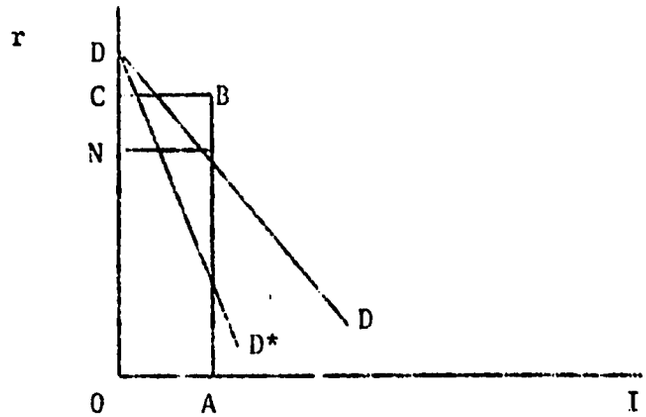

Figure 15

OA represents the total investment, OC represents the average interest rate earned on the projects. DD represents the demand curve for investment; DD* represents the marginal curve derived from DD and represents the total investment projects which would be accepted at an interest rate r which had not been acceptable at a higher interest rate. ON represents the interest rate on the marginal projects (i.e., the last projects accepted). The

average interest rate is then found as the average interest rates on all projects which are accepted when the marginal interest rate is ON; it is the average of r over the DD* curve from M (the interest rate which just makes the best project acceptable) and N the interest rate of the worst project accepted. The returns to labor are fixed. As we move along the DD curve, we use different amounts of labor, but these amounts are absorbed into the rest of the economy with no change in wage rates (since we have assumed the wage rate is fixed!). Then the contribution to national product of the projects depends only on the returns to capital!

Consider the next case where the supply of labor is fixed. Then the situation is different from that represented in the previous paragraph. The wage rate relevant to the projects is now found by the intersection of the project demand for labor (see DD in Figure 13) and the fixed labor supply. Since this intersection point corresponds to a particular set of projects, the selection procedure is complete.

In the general case we add the project demand for labor to the labor demand from existing productive facilities and determine the intersection between the total supply of labor and the total demand for labor. This gives the equilibrium wage rate and, consequently, the equilibrium point on the project demand for labor curve. Again, as each point on the project demand for labor curve determines a set of projects, the selection process is complete.

In the last two cases the change in national product brought about by the projects will vary with the wage rate, which is affected by the particular group of projects undertaken through the project labor demand curve. However, there is no conceptual difficulty here; the formulation is simply more involved. We have, therefore, completed the analysis where we have two factors of production to be allocated among the projects. In both the single factor and the double factor case, we note that there is (are) equilibrium point (s) in the factor markets which determine the set of projects which are to be undertaken.

An important conclusion which may be drawn from the above analysis is that if we knew in advance the equilibrium wage rate and the equilibrium interest rate, the selection criteria would be simply to do any project which shows a surplus when labor is valued at the equilibrium wage rate and the capital cost determined by the equilibrium interest rate. This conclusion holds for any capital market ranging from the internal attitude of the entrepreneur, to the corporation investing undistributed profits, to the government investment budget, or to the economy as a whole.

An analysis similar to that given above has been provided by Cookson[1/] for more complicated cases. He has shown that equilibrium investment levels and interest rates will be established for the following cases: (1) the price of capital goods is not fixed, but varies with the investment volume;

1/ Cookson, Forrest C., Jr., "Notes," op. cit.

(2) there are restrictions on capital expenditures for two periods.[1/]

The two-period case can be recast to represent two separate markets in which allocation is to take place at the same time, but for institutional reasons transfers of resources between the two markets is not possible. This is an important case because it covers the situation when the government takes money from the private sector through taxes and allocates it to its own projects. Under these conditions equilibrium is found in each market, but it is not an optimal allocation of capital for the whole economy. If, however, we make a second best assumption, i.e., that it is not possible to improve on the allocation, the problem is solved at some cost in economic welfare. The question arises whether we should allow the non-optimal character of the resulting allocation to affect the demand schedules for investment in other sectors. The answer is no. So long as the second best constraint is accepted (the fixed allocation between the two parts of the capital market), it is not possible to do better than to use the funds within the sector optimally, to choose the best collection of projects available. Thus, the important conclusion is reached that the selection of a project depends on the interest rate of the capital market in which the project is being considered: there is no significance on the project level to the non-optimality of the allocation of capital between separated capital markets. The conditions under which this conclusion applies are often present in less developed countries.

1/ A similar case is examined in Lorie, James H. and Savage, Leonard J., "Three Problems in Rationing Capital," The Journal of Business, Vol. XXVIII, No. 4 (October, 1955), pp. 229-39.

In the previous examples of achieving equilibrium in the capital market, it has not been discussed how the decision is made about whether an individual project (or a group of projects representing different ways of doing the same thing) should be carried out. This problem is discussed below in the framework of the selection criteria proper and, consequently, is omitted here. The problem of determining equilibrium will be returned to when the capital budgeting problem is dealt with; in particular, administrative procedures by which project selection should proceed will be suggested. What is critical to remember from the above discussion is that all project selection procedures are, in fact, attempts to achieve equilibrium in a capital market. The capital market for an economy may fragment into several subsidiary markets which have greater or lesser degrees of interaction. In this case, the overall capital market may not achieve equilibrium, although each individual market reaches equilibrium. Since equilibrium requires the analysis of both the supply and demand situation, one should always be quite clear on what represents the supply side and what represents the demand side of the given market.

2. The Investment Process in Different Economic Systems

The possibility of the division of the capital market into submarkets was noted in the previous section. Such fragmentation will be determined in large part by the system under which the economy is organized. Four different systems may be usefully distinguished.

(a) Perfect Competition: Investment theory in perfectly competitive markets centers around two different concepts: The entry of new firms and expansion of old firms as a result of technological changes. Entry of new firms arises when existing firms are earning profits above the overall average for the economy. The investment criterion here is straightforward: The short term, above average, profits provide an opportunity for investors; this opportunity is quickly exploited on the assumption that there are entrepreneurs ready to step in. When there is technological change and new productive processes are available, investment will take place if above average profits can be earned with the new techniques. Again the criterion for investment is that there is some surplus above the cost of capital. Since the theory of the firm is usually studied in a timeless environment, it suffices to consider the consequences in a "typical" year. Problems arising from dynamic considerations are not relevant in the static theory. The model of investment in this case assumes widespread knowledge of opportunities and the existence of entrepreneurs with the requisite business and technical knowledge, just the qualities which are most lacking in the less developed countries. For reasons which were discussed in Part IV, there may be factors which cause the investments made not to achieve the desired effects in the perfect competition model.[1/] The key concept which arises from the analysis of the competitive case, though, is the decentralization of the investment decision-making process.

1/ Bator, F. M., "The Anatomy of Market Failure," The Quarterly Journal of Economics, Vol. LXXII, No. 3, (August, 1958), pp. 351-79.

(b) The totally planned economy: In the totally planned economy the political authority makes all investment decisions. From a formal standpoint there may be little difference between a totally planned economy and a perfectly competitive economy if the desired final demands are the same and if there are no external economies or diseconomies. The case for centralization of investment decision making must rest upon either a belief that the final demands established by the market do not conform with what is best for the country or the prevalence of externalities.[1/] Finally, the planned economy may improve the supply of entrepreneurial talent by creating incentives within the governmental hierarchy or it may improve the flow of information about investment opportunities, two of the important reasons the competitive investment process breaks down.

(c) The corporation-dominated economy: In between the totally planned and the perfectly competitive economies is the class called here the corporation-dominated economy. Each corporation is conceived of as an organization owning a variety of productive facilities; it may use some of its profits to expand into any field where it expects to make above average profits. Within the corporation there is in effect a miniature capital market in which available funds are distributed to alternative investments

---

1/ Market failure for pricing decisions takes place in the presence of oligopolistic organization of the industry. The lack of competitiveness in the product market may, however, be present when there is a virtually perfect capital market; then average profit rates in all industries will tend towards equality (abstracting from risk) and investment criteria will be the same as in the perfectly competitive case; i.e., does the new investment earn above average profits?

according to profitability criteria. This internal allocation of funds is clearly a perfect capital market given the information available to the corporation. Outside of the corporation, however, the capital market may be far from perfect. For an economy in which a private sector exists alongside a public sector, the government's investment decisions are reached along bases very much like those of the private corporation. It is thus no surprise that the literature on business decision making contains a large body of ideas relevant to the government of less developed countries.

(d) The open, less developed economy: One of the characteristics of this type of economy is that investment decisions are made in a manner rather similar to the corporation-dominated economy. The capital market is fragmented into smaller, more or less perfect, markets within which decisions are made as in the corporation-dominated economy. Each ministry, or the planning agency if it has sufficient power, is a major investment decision maker; development banks or development corporations may also act as miniature capital markets, attempting to allocate capital perfectly within the limits of their funds and knowledge. The private foreign capitalist will act in much the same way although he allocates capital over the whole world rather than within a particular country. The result is that the investment process is neither fully decentralized nor is it centralized, but lies somewhere between, with each major economic force tending to act independently.

This brief survey has identified several different problems that appear in the allocation of capital which depends on the way the economy is organized. The dominant question which pervades this issue is the optimal degree of decentralization. There is no easy answer to this question.[1/]

3. Project Selection Under Three Sets of Conditions

Up to this point investment has been treated as a rather abstract, continuous process. In fact, however, investment decisions must be made for individual projects, and the conditions under which these decisions are made will vary. These conditions in a sense reflect the nature of the capital market which provides the funds for the project or projects under consideration. Three sets of conditions may usefully be identified. Decisions made within these three settings will be called the "go-no-go" decision, the choice among different ways of doing the same thing, and the capital budgeting decision.[2/] The nature of these three decisions will be examined in this section.

(a) Go-no-go: The go-no-go decision problem is typified when the project planner is confronted with a single project and he must choose whether to proceed with it. This type of project selection problem occurs rather frequently in practice. For example, a development bank has before it

---

1/ The literature is highly technical and usually studies situations which are not realistic for less developed countries. See Harrison, L., "Optimality and Informational Efficiency in Resource Allocation Processes" in Arrow, K. J., Karlen, S., Suppes, P. (eds.) in Mathematical Methods in the Social Sciences, 1959, Stanford: Stanford University Press: 1960.

2/ Lorie and Savage, 1955.

a loan request for an industrial establishment; or the ministry of public works wishes to build a road between two towns; or the manager of an electric power station must decide whether to replace a generator. In this type of problem it is assumed that there is no specific alternative. If there is a specific alternative, then it becomes a problem of the second type. However, we do assume that there is a general alternative, namely, investing the capital at some standard or average rate of return for the economy. Recalling the investment rule for the perfectly competitive economy--invest whenever there is an opportunity to earn above normal profits--it is seen that this is, in fact, a go-no go decision if there are no alternatives as to plant size or technique used. For investment problems in less developed countries, go-no go decisions usually reflect a situation where someone has suppressed a choice, since it is usually possible to think of some other way to carry out a project.

(b) Different ways of doing the same thing: A more realistic case arises when there are several alternatives to achieve the same purpose, and the question is which should be used. For example, in constructing a road there are many alternative specifications of surface type, width, drainage, maximum slope and radius of curvature, etc. Only one type of road is to be built. Which alternative should be chosen? Another familiar example occurs in the choice between thermal or hydro-electric power plants.

It is usually of some importance not to suppress the alternatives prematurely. Thus, one should not close one's eyes to some methods of production because they are uncommon in developed parts of the world, nor

should one impose on public sector projects engineering standards derived from developed countries. The examination of many different ways of carrying out the same project is essential in good project planning.

(c) The capital budgeting problem: The simplest type of capital budgeting problem is where one has a number of projects, each independent of the others, and a fixed amount of a single type of resource available in the first period. Each project requires a certain amount of the limited resource. The problem is then to choose which projects to undertake. The problem is easily generalized (at least conceptually) to include the case where there are groups of projects representing different ways of doing the same thing, where there are interactions (externalities) between projects. The capital budgeting problem appears frequently in planning literature. The prototype procedure is to suggest that all the projects be collected together and compared, choosing those which add most to the national product given the constraint. Of course, the constraint usually considered most binding in less developed countries is the availability of capital. Capital budgeting problems with multiple constraints can also be easily formulated.

B. SELECTION CRITERIA FOR GO-NO GO DECISIONS

The go-no go decision problem occurs whenever the decision maker must decide whether a project is to be carried out. A variety of criteria has been proposed for making go-no go decisions. These criteria are examined in this section, as well as some special problems in go-no go decisions (including applications to foreign aid projects and controlled projects in the private sector). Finally, some "non-capital" criteria which judge projects on bases other than capital are discussed.

1. The Basic Approach to Go-No Go Decisions

Most selection criteria which have been proposed for go-no go decisions approach the problem in the following fashion. A number (or some numbers) is calculated according to a stated rule from the data on benefits and costs of the project. This number, or criterion as it is called formally, is then fed into a decision rule which tells whether to proceed with the project. Selection criteria of this sort may differ in four respects: (1) the method of handling valuation of the benefit and cost streams; (2) the way in which the time nature of the project is taken into account; (3) the rule by which the criterion is constructed; and (4) the rule by which the decision is made. The first difference is not discussed here, this valuation problem being not directly related to the selection problem and having been previously discussed in Part IV.

Once given the data on benefits and costs of a project, the go-no go decision requires two steps: calculation of the criterion and application of the decision rule. This two-step aspect of go-no go decisions is not always treated explicitly, but herein we shall attempt to insure that both aspects of the rule are made clear.

Inherent in this two-step approach is the concept of a small capital market. The criterion rule applied to the benefit and cost data gives a number which will be called r. The decision rule is to proceed with the project if r is greater than or equal to a standard criterion value r_m. If $r > r_m$, the decision rule says "go"; if $r < r_m$, the decision rule says

"no go." The r value from the criterion can be thought of as the demand condition, and the r_m value in the decision rule can be considered a supply condition. The demand curve is thus the step function ABCD in Figure 16.

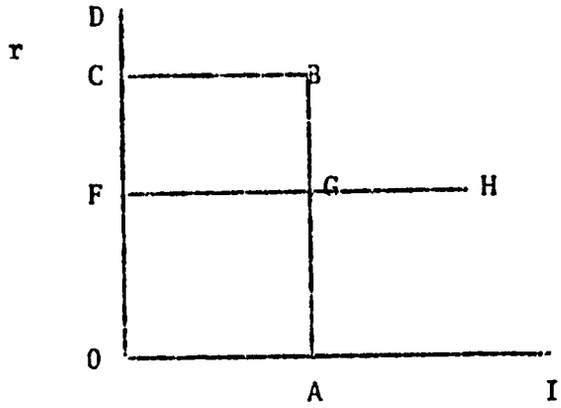

Figure 16

Here OC is the value of the criterion calculated from the project format, and OA is the size of the project. The supply curve is the line FGH where OF is the standard criterion value r_m. The intersection at G says that the size of this investment would be OA; i.e., this project would be chosen.

2. The Present Value Selection Criterion

In the section on the economic framework of project selection, it was pointed out that, while consumption may be the basis for social utility, the consumption arising from a project is not the correct concept for measuring benefits for project selection purposes. Instead, production is the benefit. When one maximizes the surplus return over costs of production, i.e., the capital earnings when productive factors are valued at opportunity cost, one also maximizes consumption. In order to be complete, we should add that the time streams of both the benefits and costs--the production

stream and the factor stream--must be discounted at the appropriate social time preference rate. Cookson[1/] has analyzed this argument in detail and has established a number of important conclusions. The complete analysis will not be reproduced here, but the more important conclusions will be presented.

The present value of a project is the stream of production discounted at the social time preference rate minus the stream of costs valued at opportunity cost and also discounted at the STP rate. The fundamental selection rule will then be: Choose a project whenever the present value of the project is greater than zero. The stream of costs for the present value calculation will include the capital expenditures at the time they are made, discounted by the STP rate, but will exclude interest payments; it will also include the cost of other scarce factors, such as labor, foreign exchange, etc., at their opportunity costs. The calculation rule for the criterion, the present value, may be stated mathematically as follows:

$$\text{(V.1)} \quad PV = \sum_{i,t} \frac{X_t - \lambda_i F_{i,t}}{(1 + r)^{t-1}}$$

Here PV = present value

X_t = output in time t

$F_{i,t}$ = amount of i'th factor used in t

λ_i = opportunity cost of i'th factor

r = social time preference rate

1/ Cookson, "Notes"

The role of capital in the present value criterion requires further explanation.[1/] Briefly, if saving is flexible, so that the capital market is perfect, the government can raise sufficient capital to insure all projects are done which have positive present values. In this case we say the opportunity cost of capital is one; that is, capital inputs are valued at their market cost. The present value criterion counts capital as a cost when it is expended. Net benefits then equal total benefits less payments to non-capital factors and for the purchase of capital goods. Depreciation and interest payments are not costs to the project since they do not represent resource use.

If saving is inflexible, there may be a shortage of saving, given the social time preference rate. In this case, the opportunity cost of capital is greater than the market value; i.e., λ for capital expenditures in the present value formula is greater than one. The opportunity cost will then be that value which when multiplied by the capital cost will just make the present value of the marginal project zero. The problem is that the present value of the marginal project may be positive rather than just zero if the market value of the capital goods is used. It is, therefore, necessary to raise the value of capital goods so that the present value of the marginal project will be zero.

1/ For a fuller discussion of the opportunity cost of capital, see Cookson, "Notes."

With the use of the present value selection criterion, the selection process breaks apart in time; we can choose projects for the current period without consideration of projects in later periods (unless there are project interdependencies). Furthermore, it is only output of the project which enters the benefit stream; thus, immediate consumption generated by the project or subsequent secondary consumption need not be considered.

A few comments should be made on the project universes. These can be as general as one wishes. In particular, the project universe can be expected to change from period to period in much the following fashion: The project universe for the first period consists of all conceivable projects, possibly subdivided into sets whose members are mutually exclusive. From the previous discussion we see that the project universe in the future is irrelevant in the maximization of social welfare. This rests on the independence assumption that the benefits of future projects do not depend on which <u>particular</u> projects are done in the first period. However, having carried out the first set of projects, we can now re-examine the projects and re-assess the benefits arising from projects in the universe for the second period. The project universes evolve as each new set of projects is carried out. All the previous remarks on the importance of a broad knowledge of the project universe are, of course, of obvious importance in this context. The fewer projects available whose present value is positive, the lower the level of saving and the slower the growth.

3. Other Go-No Go Selection Criteria

We turn next to a review of other go-no go criteria besides that of present value. Many of these other criteria have been advocated in the literature, and it is helpful to review their usefulness to the planner. Such criteria are useful to the extent they do not deviate very much from the present value method but are simpler to apply.

(a) 'Recoupment' period:[1/] The 'recoupment' period, or pay-off period (T), is defined as the time that it takes for the accumulation of cash flow (or resource flow) to equal zero. This is a measure of how long it takes to recover the initial capital. The decision rule is:

$$\text{Go if } T \leq T_m$$

$$\text{No go if } T > T_m$$

where T_m is the maximum acceptable recoupment period. Clearly the shorter the recoupment period, the better the project. The advantages of this method rest in its ease of application and, consequently, it has been proposed as a method of screening projects.[2/] Its relationship to more complex criteria is discussed by Cordon and Masse.

This criterion has been heavily criticized in the literature for two different reasons: First, it is independent of the opportunity cost of

---

1/ For discussion of this concept, see Gordon, M. J., "The Pay-Off Period and the Rate of Profit," The Journal of Business, Vol. XXVIII, No. 4 (October, 1955), pp. 253-260; Masse, Pierre, Optimal Investment Decisions: Rules for Action and Criteria for Choice, Englewood Cliffs: Prentice-Hall, 1962, chapter 2; Merett and Sykes, 1963.

2/ Edwards, Bruce, "Time Preference and Development Planning: Screening and Selection of Projects," Center for Development Planning, NPA, Document M-7883, Dev. Plan. 64-2, May, 1964 (mimeographed).

capital and the social discount rate and so neglects two of the most vital concepts in project planning. If the capital market is perfect, we can neglect the difference between these two concepts. Then the criterion is not entirely correct, since the interest rate is a supply concept for the individual project; the maximum recoupment period T_m is the appropriate supply concept for this rule and presumably reflects the opportunity cost of capital. (We return to this point later.) Second, the project net benefits after the 'recoupment' of the initial investment cost do not affect the decision rule. This is a fair criticism but can be answered by pointing out that the future may become highly uncertain after a relatively short period, and there is no reason to ascribe much value to numbers which are highly speculative; therefore, it is argued, the 'recoupment' period has the advantage that it treats the data in a manner appropriate to their accuracy.

This rule is apparently widely used in industrial investments where the reliability of long-range market forecasts is highly uncertain. It has the advantage of ease of comprehension; it is easy to apply for large numbers of decisions, and its use indicates the general lack of sensitivity of industrial investments to the interest rate. Although useful for industrial investment, this decision rule is a rather crude tool; and for classes of projects where demand forecasts are more accurate and particularly when alternative technologies exist, a sharper tool is required. Despite the crudeness of the method, its usefulness should be apparent as it is a happy compromise between data accuracy, complexity of application, and the skill levels of those responsible for decision making.

The pay-off period is useful only for point input-continuous output projects.[1/] For projects where the capital and recurrent costs are not clearly separable, it is virtually impossible to use this criterion. Consequently, it is not very helpful for agricultural projects or for projects where the distinction between investment and maintenance is not clear-cut. It is not even clearly defined for point input-point output projects. It should also be noted that it is not clear how to incorporate a gestation period into the pay-back criterion. Gordon and Dryden[2/] have explored the relationship between the pay-back period and other criteria. To investigate the relationship between the pay-back period and the present value criterion, consider a project which consists of a payment of K at the start and an inflow of net benefits of V-C afterwards. If the lifetime of the capital goods is T, then the present value is:

$$-K + (V-C)\frac{r}{1-e^{-rT}}$$

The recoupment period is $K/(V-C)$. If the present value is greater than zero, then the recoupment period is greater than $\frac{r}{1-e^{-rT}}$. Consequently, if the maximum acceptable recoupment T_m is chosen to be $\frac{r}{1-e^{-rT}}$, the decision rule for the recoupment period leads to the choice of the same projects as the theoretically correct present value criterion.

1/ For definitions and discussion of point input-point output, point input-continuous output, continuous input-continuous output projects, see Lutz, F. and Lutz, V., The Theory of Investment of the Firm, Princeton: Princeton University Press, 1951.

2/ Gordon, 1955; Dryden, Myles M., "The MAPI Urgency Rating as an Investment Ranking Criterion," The Journal of Business, Volume XXXIII, (October, 1960), pp. 329-341.

The decision rules for other criteria are usually stated so as to compare information describing the project with information describing the supply side of the market. For the recoupment period, the project itself influences both T and T_m. If one is dealing with projects of more or less the same type and with similar lifetimes, a standard recoupment period might be a useful shortcut measure for project selection. The effect of the interest rate has been absorbed in the maximum recoupment period T_m. In using the recoupment period then, it appears that the interest rate is suppressed. This apparent independence from the interest rate has made the recoupment period attractive for Soviet economists who have used this criterion for investment decision making. It is usually felt that the recoupment period criterion implies a zero discount rate. When the net benefits flow uniformly through time, however, the above argument indicates this is not the case; the interest rate instead may affect the maximum recoupment period.[1/] The lifetime of the project will also affect the maximum payback period. This is clearly the case in actual applications where the type of investment determines the acceptable maximum. We conclude from this that the maximum recoupment period depends on the country in which the investment is to take place and that one should be very cautious in using the recoupment periods of the developed countries to judge investment projects in less developed countries.

1/ Feldstein, Public Finance, 1964; Dobb, 1960.

(b) Internal rate of return or rate of return.[1/]

The internal rate of return is defined as the solution for r of the equation:

$$A_0 + \frac{A_1}{(1 + r)} + \frac{A_2}{(1 + r)^2} + \ldots + \frac{A_N}{(1 + r)^N} = 0$$

where A_0, A_1,...A_N are the net project benefits, which would be the cash flow for the private entrepreneur, of the resource flow for the public assessment of the project. The lifetime of the project is N. The decision rule is to compare the internal rate of return of the project with a minimum given rate of return. If the minimum rate of return is r_m, then the project is acceptable if $r \geq r_m$; otherwise, the project is not acceptable.

This decision rule has a long famous history originating with Bohor, Barish, and Wicksell, and developed further by Keynes.[2/] There are several difficulties with its use which should be mentioned: First, the numerical calculations are tedious to carry out. There being no simple way to solve the equation, one must proceed by trial and error attempting to find a

---

1/ Historically, the internal rate of return has been one of the popular devices for evaluation of projects. The controversy over its appropriateness as an investment criterion still goes on. The theory is lucidly presented in Boulding, K. E., "The Theory of a Single Investment," The Quarterly Journal of Economics, Volume XLIX, No. 3 (May, 1935), pp. 475-494. It is discussed in most investment analysis books; e.g., Dean, J., Capital Budgeting, New York: Columbia University Press, 1951; Merret, A. J., and Sykes, A., The Finance and Analysis of Capital Projects, New York: John Wiley, 1963.

2/ Keynes, J. M., The General Theory of Employment, Interest and Money.

discount rate which makes the expression positive and one that makes it negative. Then by interpolation, the internal rate of return can be found.[1/] Second, there may exist several solutions of the above equation for r.[2/] This phenomenon has been discussed widely, and the best conclusion seems to be that the non-uniqueness phenomenon complicates, but does not in itself invalidate, the use of the internal rate of return. Multiple values for the internal rate of return may appear whenever the stream of net benefits changes sign more than once.

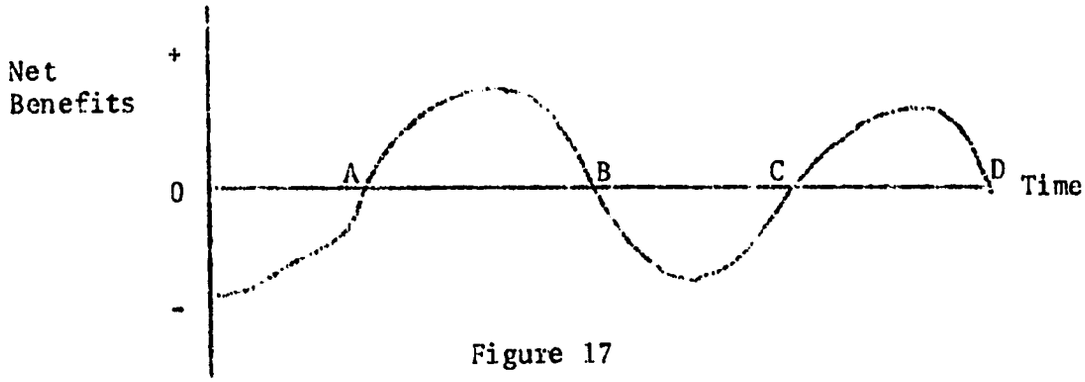

Figure 17

Figure 17 represents the time flow of net benefits over time. Notice that the benefits are negative at the start, become positive at A and then become negative at B, positive again at C, and finally the project terminates at D. If we calculate the present value for all different interest rates, the result may be as shown in Figure 18.

1/ There are many explanations of this procedure and discussions of ways of making the approximations: Barish, Norman N., Economic Analysis for Engineering and Managerial Decision Making, New York: McGraw-Hill, 1962; Taylor, George A., Managerial and Engineering Economy, Princeton: Van Nostrand Company, 1964, chapter 8.

2/ Boulding, 1935; Lorie and Savage, 1955; Wright, J. F., "Notes on the Marginal Efficiency of Capital," Oxford Economic Papers (New Series), Volume 15, No. 2 (July, 1963), pp. 124-129; Wright, J. F., "Some Further Comments on the Ambiguity and Usefulness of Marginal Efficiency as an Investment Criterion," Oxford Economic Papers (New Series), Vol. 17, No. 1 (March, 1965), pp. 81-89.

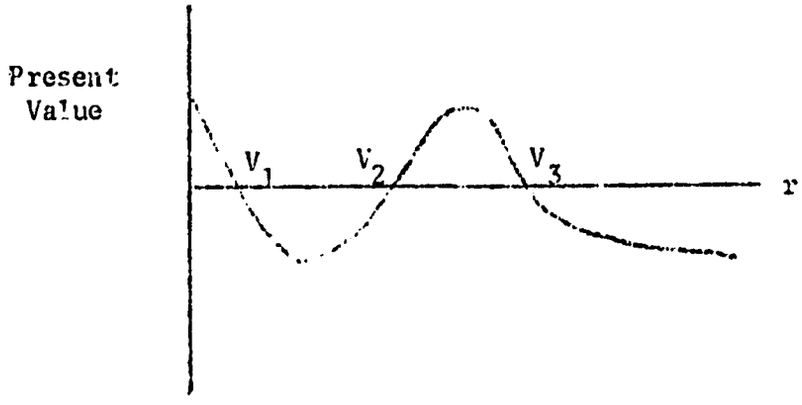

Figure 18

The internal rate of return is then those values of r at which the present value is zero; namely, V_1, V_2, V_3. When the interest rate is very large, then the present value is negative since the initial capital costs dominate the later benefits; when the interest rate is very low, then the present value is usually positive, corresponding to the fact that, if there is no discounting, one normally gets more from the project than one puts into it. Thus, between the very low value of the interest rate and the very high value the present value falls from positive to negative. The internal rate of return will be where the present value is zero; the present value may oscillate back and forth between positive and negative values, in which case we will have multiple values for the internal rate of return.

Ideally, one would like to derive the conclusion that the present value rule (i.e., 'go' if the present value is positive) implies the internal rate of return rule (i.e., 'go' if the internal rate of return is greater than a predetermined value). Clearly, if the minimum acceptable value for the internal rate of return equals the social time preference

discount rate used to calculate the present value, and if there is only one positive internal rate of return, the rules are identical. This is easily seen from Figure 19.

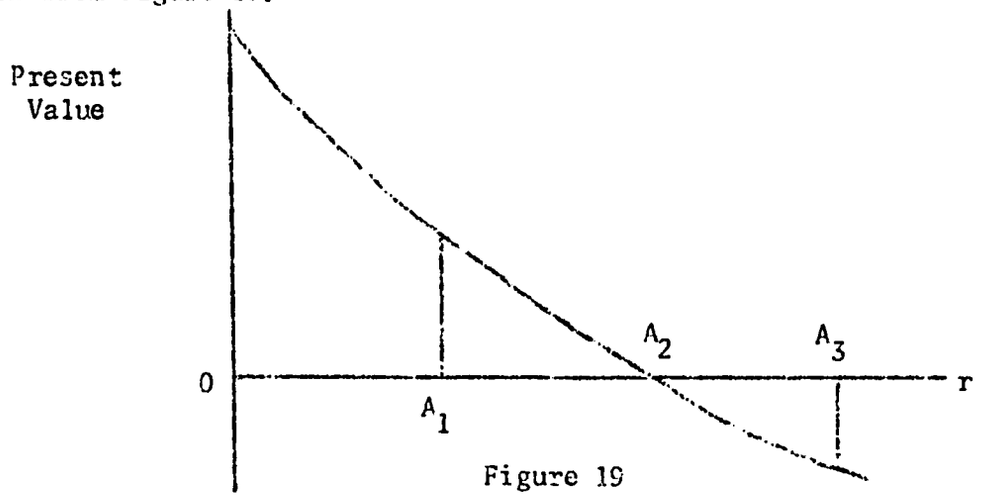

Figure 19

The present value is positive at A_1 and negative at A_3. The project should be chosen if the interest rate is A_1, which would be the case with the internal rate of return rule (since $A_2 > A_1$). Similarly, the project should be rejected if the interest rate is A_3. This would also be the case with the internal rate of return rule (since $A_3 > A_2$).

The difficulty begins when there are multiple values of the internal rate of return. Referring to Figure 18, it is clear that if one knew only the internal rate of return at V_2, then it would be easy to make a mistake by rejecting the project when, in fact, it should be accepted. Consequently, the decision rule must be restated: Let $r_1, r_2, \ldots r_4$ be the internal rules of return. We assume that in the initial period there is a negative net benefit, but that the sum of net benefits is greater than 0. Then, if r_m is the given rate of return, the decision is go if V_m falls in any of the intervals:

$$0 < r_1, r_2 < r_3, r_4 < r_5 \ldots$$

These are just the intervals within which the present value is positive.[1/] Projects will often manifest this behavior of alternating positive and negative net benefits. For example, if there are costs in terminating the project, benefits may be negative at the end of the project as well as at the beginning. Projects which require purchases of capital equipment from time to time during the full life of the project may also exhibit this alternation in the sign of net benefits. Finally, we should note that the alternation in the sign of net benefits does not insure that there will be more than one real positive solution for the internal rate of return, but it does make it possible.

The internal rate of return has been defined by taking a project and finding what interest rate made the present value zero. The lifetime of the project was taken as given. It can be shown[2/] that, regardless of the lifetime of the project, the internal rate of return gives the same answer as the present value for go-no go decisions when the minimum acceptable internal rate of return is the same as the discount rate used to determine the present value. This is a property which results from the fact that we have a go-no go decision; for other decision situations things are not so straightforward.

1/ We have assumed there are no instances of roots at which the slope of the present value function is zero.

2/ Cookson, "Notes."

Another difficulty with the internal rate of return that is readily apparent is the failure of the criterion to take any account of time preference. If the minimum acceptable internal rate of return is the social time preference rate, then this aspect is taken into account. But if the social time preference is not a constant, but changes with time, there is no way to reflect this in the internal rate of return approach. So long as it is the welfare of the society which is to be maximized, one cannot escape the necessity for including time preference in the evaluation of the project; this neglect is the greatest problem in utilizing the internal rate of return as a tool in development planning. An alternative that might occur to one is to use the social time preference to discount the net benefits and then to calculate the internal rate of return of the result. This procedure is perfectly valid although the decision rule must then be changed: The project should be accepted if the internal rate of return is positive.

It is useful to introduce here the Fisher concept of the rate of return over cost.[1/] The rate of return over cost is really a comparison between a project and an alternative investment (not necessarily a different way of doing the same thing). The rate of return over cost is just that interest rate which makes the present values of the two projects equal.

1/ See Alchian, A. A., "The Rate of Interest, Fisher's Rate of Return over Costs and Keynes' Internal Rate of Return," The American Economic Review, Volume XLV, No. 5 (December, 1955), pp. 938-943.

In general, this will be different from the internal rate of return of either of the investments. In calculating the rate of return over cost, it is important that the projects have the same lifetime.[1/] When the alternative project is some standard project, the Fisher concept becomes relevant to the "go-no go" decision categories. Suppose that the alternative is a bond with a lifetime of T years which costs $M and returns $N per year. Its present value is:

$$-M + \frac{N}{r}(1 - e^{-rT})$$

The present value of the project under consideration will be PV(r). The present values are equal when:

$$PV(r_F) = -M + N\,\frac{1 - e^{-r_F T}}{r_F}$$

This gives an equation for r_F, the Fisher rate of return over cost. The internal rate of return, r_I, is given by the solution of $PV(r_I) = 0$. If, at the Fisher rate of return, the project has a positive present value, then $r_F < r_I$. The bond market interest rate, N/M, is the internal rate of return for the bond. Assume that there is a perfect capital market so that N/M is the correct discount rate to use for selection. Then two cases are possible, the discount rate or bond market interest rate can be less than the internal

---

1/ We return to this point in the next section. See Robinson, Romney, "Interest-Return over Cost or Internal Rate: Comment," The American Economic Review, Volume XLVI, No. 5 (December, 1956).

rate of return:

$$r_F < N/M < r_I$$

or the discount rate can be greater than the internal rate of return:

$$r_F < r_I < N/M$$

The "go-no go" decision rule for the internal rate of return would tell us to proceed with the project in the first case but not in the second. Taken by itself, the rate of return over cost does not provide a decision rule. If one wishes to build up a demand for investment schedule, the comparison of the economy's discount rate with the internal rate of return of the project is the correct procedure. The rate of return over cost is not a relevant concept for go-no go decisions. Rather, its usefulness as a concept appears when one is ranking projects.

The dispute over the "right" criterion for the go-no go decision has centered on the internal rate of return versus the present value. In fact, there are many examples that show different rankings of projects are given by these two criteria; but as we have previously proved within the go-no go framework, the two rules give the same result. The celebrated non-optimality of the internal rate of return arises from two situations: A comparison of different ways of doing the same thing[1/] or a set of investment opportunities,

---

1/ Lutz and Lutz, 1951, chapter 2.

including the possibility of purchasing bonds in the money market.[1/] Neither of these cases is relevant to the problem under consideration.

The internal rate of return is not a good criterion since it, at best, tells us no more than the present value criterion and is considerably harder to calculate. Despite this, it continues to be recommended by many as a useful criterion in investment decision-making. There is no real use for it in go-no go decisions where its use is complicated by the possibility of finding several different values. We can conclude, therefore, by rejecting the criteria as appropriate to the project planning problem. However, we shall return to a discussion of its usefulness in the next two parts.

(c) Profitability or equivalent annual returns[2/]

If a project has an annual net return of B, a capital cost of K, and a lifetime of T years, then we define the profitability as the ratio of net benefits less depreciation to the capital cost. If the depreciation is D, then this ratio is $\frac{B - D}{K}$. The decision rule is to compare this ratio with a given profitability r: If the project profitability is greater than the standard profitability, then the project is accepted; otherwise, it is rejected. How does this compare with the present value method.

1/ Hirschleifer, J., "On the Theory of Optimal Investment Decision," The Journal of Political Economy, Volume LXVI, No. 4 (August, 1958), pp. 329-352; Bailey, "Formal Criteria for Investment Decisions," The Journal of Political Economy, Volume LXVII, No. 5 (October, 1959), pp. 476-488.

2/ Merret, A. J., and Sykes, A., 1963.

The present value of the project is:

$$-K + B\left(\frac{1 - e^{-rT}}{r}\right)$$

If r, the discount rate in the expression for present value, is the minimum acceptable profitability, then the condition that the profitability be greater than r is:

$$B > rK + D$$

The condition that the present value is positive is:

$$B > \frac{rK}{1 - e^{-rT}}$$

The two criteria will be the same, therefore, <u>if</u>

$$D = \frac{rK}{1 - e^{-rT}} - rK$$

$$= K\left(\frac{r}{e^{rT} - 1}\right)$$

This depreciation rate is just that which, if invested at a return r will provide the firm with $K at the end of T years (the so-called sinking fund depreciation rule). If rT is small, then:

$$\frac{r}{e^{rT} - 1} \doteq \frac{1}{T}$$

That is, the sinking fund is about the same as straightline depreciation. We conclude that if the benefits flow in a regular manner, then, provided that sinking fund depreciation is taken as a cost, the go-no go rule gives the same answer for both the profitability and the present value criteria.

This method of project evaluation is very popular, since it avoids discounting procedures and is rather simple to understand. Many find this criterion more sensible since depreciation is explicitly counted as a cost. For projects with rather uncertain time paths of costs and benefits the equivalent annual return method is quite proper. For projects with significant changes over time in the resource flows into and out of the project it is best to use the present value criterion in order to take account of the time changes.

When applied to development planning, the profitability is usually called the social marginal product.[1/] The social marginal product, or SMP, is simply the profitability when due allowance is made for the indirect benefits and costs, as well as the adjustment of factor prices. The SMP alternatively can be calculated using present values of benefits less present values of costs, divided by the capital cost. This essentially assumes the project can be completed in one year. When discounted costs are used, depreciation should not be included. In addition, the decision rule now becomes: Proceed with the project if the SMP is greater than one. When so interpreted, the SMP criterion becomes identical with the present value.

1/ Kahn, A. E., "Investment Criteria in Development Programs," The Quarterly Journal of Economics, Volume LXV, No. 1 (February, 1951), pp. 38-61; Chenery, Hollis B., "The Application of Investment Criteria," The Quarterly Journal of Economics, Volume LXVII, No. 1 (February, 1953), pp. 76-96.

(d) Benefit-Cost Ratios: There are several concepts of the benefit-cost ratio. We will first give three different concepts of the benefit-cost ratio and find the conditions under which they lead to the same results. Then we prove that the benefit-cost criterion leads to the same results as the present value criterion when the capital market is in equilibrium but not otherwise. For each benefit-cost ratio the decision rule is: Proceed with the project if the benefit-cost ratio is greater than some specified ratio; otherwise, do not.

(i) If the project has a perpetual stream of benefits, V per annum, and a perpetual stream of costs, C per annum, and the capital cost all occurs in the initial period, the capital goods last forever and the cost of capital is ρ% per annum, then the benefit cost ratio is $\frac{V}{C + \rho K}$. There is no depreciation term included in costs since the capital goods have infinite lifetimes. The cost of capital should be interpreted as the opportunity cost of capital adjusted to a per annum ratio. Benefits and costs can include any relevant indirect effects. This ratio is meaningful if the project has a steady flow of benefits and costs.

(ii) If the capital goods used in the project have a finite lifetime, then the benefit cost ratio is written:

$$\frac{V}{C + \rho K + D}$$

where D is the depreciation change. This is just an obvious generalization of the first version of the benefit cost ratio.

(iii) Finally, let V be the present value of the benefits and $\bar{c}$ the present value of the costs, not including the initial capital costs K. Then the benefit cost ratio is:

$$\frac{\bar{V}}{\bar{c} + \mu K}$$

where μ is the opportunity cost of capital. The annual opportunity cost of capital ρ is related to the opportunity cost μ by the fact that the discounted value of the ρ stream equals the cost μ : $\mu = \rho/r$. As usual, when present values are used, there is no depreciation change.

First, we find the conditions for the (ii) and (iii) versions of the benefit cost ratio to be the same. The present value $\bar{V}$ is:

$$\bar{V} = \frac{V}{r}(1 - e^{-rT})$$

and the present value of the costs $\bar{c}$ is:

$$\bar{c} = \frac{c}{r}(1 - e^{-rT})$$

Then the (ii) ratio becomes:

$$\frac{\bar{V}\dfrac{r}{1 - e^{-rT}}}{\bar{c}\dfrac{r}{1 - e^{-rT}} + D + \rho K}$$

This will be the same as the (iii) ratio when

$$\frac{(D + \rho K)\ (1 - e^{-rT})}{r} = \mu K$$

This gives:

$$D = \left(\frac{\rho r}{1 - e^{-rT}} - \mu\right)K$$

When the opportunity cost of capital, μ, equals one, the discount rate, r, equals the opportunity cost of capital expressed as an annual rate, ρ, and the depreciation term becomes just that given if depreciation is estimated with the sinking fund method. The depreciation rate based on the sinking fund method is:

$$\frac{r}{e^{rT} - 1}$$

which, as previously mentioned, is approximately 1/T. Therefore, when the opportunity cost of capital equals the discount rate, it makes no difference if we express the benefit cost ratio with discounted costs and benefits or if we use the annual flows and include the cost of capital and the sinking fund depreciation. When there is a divergence between the opportunity cost of capital and the discount rate, the situation is different. If the benefit cost ratio is calculated as:

$$\frac{\bar{V}}{\bar{c} + \mu K}$$

the decision rule is: Proceed with the project if the benefit cost ratio is greater than one. This is just the same as the present value decision rule in an imperfect capital market (i.e., $\bar{V} - \bar{c} - \mu K > 0$). If, however, the ratio is calculated as:

$$\frac{\bar{V}}{\bar{c} + K}$$

then the correct decision rule is not so clear. Formally, the rule would be: Proceed if the benefit cost ratio is greater than

$$1 + \frac{(\mu - 1)K}{\bar{c} + K}$$

This rule is of no use to us since the comparison value depends on the specific project undertaken. A similar conclusion is reached when we use the benefit cost ratio with annual flows.

The suggestion has been made by Eckstein[1/] and Feldstein[2/] that the correct decision rule in imperfect capital markets is to proceed with the project if the benefit cost ratio is greater than the ratio of the opportunity cost (at an annual rate) to the social time preference. In our notation, this corresponds to using the value of μ as the decision rule. This is valid if the benefit cost ratio is calculated as $\frac{\bar{V} - \bar{c}}{K}$; i.e., net benefits to capital costs. (This, of course, is just the profitability, or SMP.) But if the ratio is calculated as $\frac{\bar{V}}{\bar{c} + K}$, then this is not a correct decision rule.

1/ Eckstein, 1961.

2/ Feldstein, Public Finance, 1964.

The benefit cost ratio concept developed by Eckstein[1/] assumes that capital market imperfections extend into the future and that the project is regularly a drain on constrained funds. Then the total costs must be valued at the opportunity cost of capital appropriate to the period. If the opportunity cost of capital is constant in time, then the true benefit cost ratio is:

$$\frac{\bar{V}}{\mu\bar{c} + \mu K}$$

and the decision rule can obviously be stated: Proceed with the project if the benefit cost ratio $\frac{\bar{V}}{\bar{c} + K}$ is greater than the opportunity cost of capital μ.

There is no particular reason to use a benefit cost ratio concept for project evaluation. Its importance arises from its early use in the United States to determine which water resource projects were economic. But as a concept for use in project planning in less developed countries, it has no advantages over the present value criterion. Furthermore, since its use in choosing among different ways of doing the same thing or the capital budgeting problem is dangerous and can easily lead to incorrect results, it is probably better not to use this criterion in project planning.[2/]

1/ Eckstein, Otto, 1958.

2/ For the dangers of using ratios as indicators of importance, see McKean, 1958; also, Radner, 1963.

(e) The capital output ratio: From time to time the capital-output ratio has been suggested as a selection criterion. This is defined as the capital cost divided by a representative annual value added. The reason for its use is to emphasize that payments to labor are a benefit from the project and that it is unreasonable to include only the profits of the project. The fallacy in this approach has been previously discussed, but a brief review is made here from a slightly different viewpoint. First, if the opportunity cost of labor is zero, then the value added is just the same as profits. (The fact that labor obtains some of the profits due to a non-zero wage rate is quite beside the point; that is a question of distribution of the profits among various potential recipients.) Since this condition holds in many less developed countries, the operational significance of using the capital-output ratio rather than SMP may be slight. Therefore, we consider the case where there is an opportunity cost for labor; the demand for labor is sufficiently high that wages must be paid or workers will take advantage of other opportunities. Another way to say this is to remember labor is scarce and if there were more labor available, output would be higher.

Consequently, when we examine a project, if it has a high labor input, we know that, because it uses labor, other projects cannot be carried out; the use of labor by a project is a cost to the society. If we choose to ignore the opportunity cost of labor in project evaluation by using the capital-output ratio, then we would be indifferent between two projects with the same value added but with different labor requirements. Properly

we should not be indifferent since the relative scarcity of capital and labor may be such that the labor intensive project is better (or worse). The use of the opportunity cost of labor corrects the value added for labor scarcity and then we choose projects according to their capital scarcity. Of course, nothing prohibits us from proceeding in the other direction, but in principle we should obtain the same answer.

The point is that to maximize output we must allocate according to scarcities; we are not trying to maximize output from any particular project but, rather, from all of the projects chosen. It is extremely important in project evaluation to remember that criteria which emphasize profitability in one form or another are not ignoring the labor contribution but instead are trying to use the available labor to obtain as much output as possible.

(f) The Tinbergen criterion:[1/] Tinbergen emphasizes the critical point of project selection by focusing on the national income effects of projects. His argument is: Consider an economy with a private sector; the government makes an investment and this changes the basic structure of the economy. As a result, a new general equilibrium will set in and the level of national income will have changed. If we consider various sets of projects, we can ask: Which set will enhance national income the most?

1/ See Tinbergen, Jan, 1956. Chapter 5 and Model 20. Also, Tinbergen, J., "The Appraisal of Road Construction: Two Calculation Schemes," The Review of Economics and Statistics, Volume XXXIX, No. 3 (August, 1957), pp. 244-249. For an application of this, see Bos and Koyck, 1961.

The project (or projects) have two consequences: (1) In themselves, they increase output; (2) they induce in the private sector changes in supply and demand (possibly through investments). Both of these consequences must be taken into account in project selection.

The most important point raised here is the induced investment. In many types of projects this induced investment dominates the direct consequences of the project, as well as the indirect effects arising from changes in supply and demand with the existing productive facilities. What Tinbergen proposes is to tackle the project planning problem explicitly within this framework. Although there exists a framework and some applications to specific types of projects, the general approach has apparently been too comprehensive to be usable. Nevertheless, recognition of the interactions between development projects undertaken by the government and the resulting induced investments by the private sector is an important phenomenon to keep in mind.

The relevant go-no go criterion can be simply described: If the induced investment would not otherwise have taken place (in any manifestation) then the entire benefits from the induced investment can be attributed to the project. (This is equivalent to recognizing that the opportunity cost of the induced investment was zero.) If the investment would have taken place anyway, then only the benefits directly derived by the project should be counted. When the problem is posed as a comparison of groups of projects, then one can study national income maximization as Tinbergen does; it is only when the analysis is pushed to individual project criteria that the profitability concept becomes fundamental.

(g) Some other criteria: This section presents very briefly some other concepts which have been proposed.

(i) Solomon criteria:[1/] Solomon has proposed not a single criterion but four, which should all be used in selection decisions. The first two relate to projects viewed from the private businessman's point of view, and the third and fourth reflect the national or social point of view. Solomon is concerned primarily with projects to be undertaken by private business, and his point is that an attractive project is one that looks promising from both the private and public points of view. He proposes, therefore, that two internal rates of return be calculated from the private viewpoint. The first is on total resources invested in the project, including equity and borrowing. This return measures the overall profitability and, thus, is of interest to the financing agent. The second is the internal rate of return to the entrepreneur. It, therefore, measures the profitability to the person who borrows money to organize the project.

The two measures that Solomon proposes for evaluation from the public point of view are what he calls the national gross rate of return and the surplus rate of return. These two measures are defined somewhat obscurely, but they appear to be, respectively, the ratio of value added per year to investment inputs and the ratio of uncommitted cash flow per year to investment inputs. Solomon suggests that the national gross rate of

---

1/ Solomon, Morris J., Project Analysis, A System for Shaping and Appraising Projects with Special Application to Newly Developing Countries. Organization of American States. To be published in 1966. See particularly Chapter VII.

return reflects the goal of maximizing output per unit of invested capital, and the surplus rate of return reflects the availability of funds for further investment. The argument about maximizing output has been discussed above in this paper; present value is basically the correct approach to maximizing the discounted stream of consumption and is, therefore, superior to a criterion which uses national income growth as its goal. The argument about the possibility of increasing funds for investment is a very different one. Present value is the correct criterion on the assumption that future factor supplies are independent of projects chosen in the present. The surplus rate of return criterion assumes the opposite: Projects chosen now importantly affect the savings available for investment later. Solomon's argument thus becomes similar to the Galenson-Leibenstein argument which is examined at the end of this section.

The decision rule which should be used with the four criteria proposed by Solomon is not stated explicitly. Apparently the project selector has some room for judgment as to the relative importance to be attached to the different rate of return criteria and to other intangibles.

(ii) Sen criterion:[1/] Sen's basic argument is directed at choice between different levels of capital intensity. However, we can usefully note his concept since it is of general application. Sen's analysis is

---

1/ Sen, A. K., Choice of Techniques - An Aspect of the Theory of Planned Economic Development, Oxford: Blackwell, 1960; Sen, A. K., "Some Notes on the Choice of Capital Intensity in Development Planning," The Quarterly Journal of Economics, Volume LXXI, No. 4 (November, 1957), pp. 561-584; Sen, A. K., "Choice of Capital Intensity Further Considered," The Quarterly Journal of Economics, Vol. LXXIII, No. 3 (August, 1959), pp. 466-484.

really at an aggregative level; he examines a specific rational picture of the economy and investigates investment within that picture. The basic point is that one should avoid maximizing immediate output or maximizing the rate of growth but, instead, should maximize output of consumption goods for some specified time period. This means that one must balance investment between the capital goods' and the consumption goods' sectors; too much investment in consumption goods hurts future consumption, and too much investment in capital goods hurts present consumption. Sen shows how to work out the optimum.[1/]

Sen's approach is not immediately useful for operational project planning. The reason for this is, however, relevant. The approach to project planning that has been followed here can be described as separation of the valuation problem from the selection problem. When one wants to solve these problems simultaneously, or alternatively to avoid completely the valuation problem, then the approach used by Sen is typical of how this can be done.

iii. Feldstein criterion:[2/] Perhaps the most sophisticated criterion available has been developed by Feldstein. Since it is too

---

1/ This same conclusion is reached via a different road in Findlay, R. F., "Capital Theory and Development Planning," Review of Economic Studies, Vol. XXIX, No. 2 (February, 1962), pp. 85-98. Also, see Sriniysan, T. N., "Investment Criteria and Choice of Techniques of Production," Yale Economic Essays, Volume II, No. 1 (Spring, 1962), pp. 59-115.

2/ Feldstein, Oxford Economic Papers, 1964.

complex to be used in actual planning, we do not develop this concept fully but shall content ourselves with a qualitative discussion of its characteristics. Feldstein starts from the position of maximizing all future consumption as the criterion for project solution. Then he determines the effect on consumption of an investment; the induced consumption is traced out so that the total effects can be assessed. Having derived the basic effect on future consumption of a dollar of investment, the consequences of the investment can now be worked out. This is done by examining the benefits and costs of the project and their induced consumption. This leads to an expression for the value of a project as its contribution to consumption now and in the future. Given a group of projects, one then attempts to maximize the total induced consumption. To achieve this maximization one would like to have the opportunity cost of constrained factors.

This approach differs from ours in one particular: Feldstein maximizes the contribution of a set of projects having worked out the consumption effects of each separately; in so doing, he has implicitly made an assumption as to the supply of saving in future periods and, consequently, must properly introduce the opportunity cost of capital in all future periods. On the other hand, we have derived the criteria through the maximization of consumption and use these criteria to select projects. When we assume that future capital markets are not rationed, i.e., the capital market is perfect, then saving rates become irrelevant; all that

matters is the present value of the project. But when the capital market is imperfect, it is important to make explicit recognition of the opportunity cost of capital in various time periods as part of the selection criterion.

We summarize the argument above: We have shown that for go-no go decisions, most criteria give the same result when properly interpreted. However, the most useful and among the easiest to apply is the present value. The present value go-no go criterion tells us to accept the project whenever its present value is positive. The motivation behind the formulation of selection criteria has usually rested elsewhere than the go-no go decision. These same criteria, therefore, reappear in discussion of the other two selection problems.

(h) Non-Capital Theory Approaches

Some criteria have been proposed which focus on factors in development other than current investment to generate future income (or consumption). Two criteria which are often suggested in oral discussion with planners are employment increase and foreign exchange earnings.[1/]

The employment criteria would be: Choose that set of projects which increases employment the most for a specified time period. There is no clear concept of a discount rate which should be used to compare employment

---

1/ For example, see Tinbergen, J., Central Planning, New Haven: Yale University Press, 1964, Table 18, p. 142.

at different times, so it is necessary to choose a fixed period of time (the planning period), and it is within that period that the employment is to be maximized. Each project then has a total employment (manhours) generated over the specified time period. This total employment represents the benefits from the project. It is still possible to work out an "opportunity cost" of capital which we will call λ. The go-no go criteria then becomes: Go if $\bar{L}_i - \lambda K_i > 0$; where $\bar{L}_i$ is the total employment generated by the ith project during the planning period and K_i is the capital cost of the ith project. The significance of this procedure is that we are investing in projects to produce employment, not output.

The foreign exchange criterion is formulated in exactly the same way: For each project the net foreign exchange contribution is determined and the collection of projects which makes the greatest contribution to foreign exchange over the planning period is chosen. The criterion for the decision is just as before: Go if $\bar{E}_i - \lambda' K_i > 0$, where $\bar{E}$ is the net contribution to foreign exchange of the ith project during the planning period and λ' is the appropriate opportunity cost of capital.[1/]

Clearly, this approach can be extended to any quantifiable concept of benefit. In exactly the same way, we may choose projects subject to some constraint other than their initial capital cost. For example, we may

---

1/ We will discuss the methods for determining the opportunity cost in the capital budgeting section.

choose projects to maximize future consumption but within a limit on the current drain of the project on government budgetary resources. The criterion becomes: Go if $PV_i - \lambda B_i > 0$, where PV_i is the present value of the ith project; B_i is the budgetary drain of the ith project; and λ is the opportunity cost of budget resources. Under such a criterion, projects may be chosen when their present value is negative, if they generate enough additions to budget resources.

Economists have given increasing attention to the role of non-capital theory criteria in project selection. Formally these criteria can be incorporated into the selection process in three different ways: First, the level of say, unemployment could be directly entered into the social welfare function. Second, a constraint could be established such as: Maximize discounted consumption subject to a minimum amount of employment being generated.[1/] Third, the level of consumption is dropped from the social welfare function, and some other variable, such as employment, introduced to describe the level of social welfare. In this section we have followed the last approach. It is extremely difficult to follow the first approach, since we know so little about the relative values to the policymaker of higher consumption and lower unemployment. Without that information we can do very little to consider simultaneously several variables in the social welfare function except by introducing minimum acceptable levels for all variables except one.

1/ Encarnacion, Jose, Jr., "Optimum Saving and the Social Choice Function," Oxford Economic Papers, Vol. 16, No. 2 (July, 1964), pp. 213-20.

(i) Special Problems of Go-No Go Decisions

The range of applications of the go-no go decision processes is very wide. Several rather special problems are mentioned herein since they are relevant in situations which keep cropping up in planning.

(i) The stop decision: Projects which entail large investments over long periods of time provide an opportunity to stop the project if circumstances change the expected flow of costs and benefits. Whatever the decision criterion which is used, it is possible to apply it sometime before the capital construction phase of the project is completed. In so doing, the sunk costs (i.e., what has already been expended) should not be included in the costs. Consequently, a decision to stop a project will usually be made only when there is some new development of substantial importance. For example, if the original costs were underestimated due to misjudgment of some physical feature of the environment or if the expected benefits have changed due to some change in the economic situation of the country, or if for some reason the cost of capital (however it is incorporated in the project) changes substantially, then a project may be found to be no longer feasible and further expenditures are no longer justified. Stop decisions are usually difficult to manage since practical opinion is that when one has put so much into a project it should not be abandoned. The correct procedure is to ignore what has been spent in the past and is not recoverable and instead consider only additional costs and revenues. With changed conditions, there is no necessary reason for the decision to be either alternative.

In determining whether to stop or continue, the stop alternative may have additional costs required to bring the project to a halt. These costs could make the stop decision appear to be undesirable. It is thus possible that applying a particular go-no go rule to the alternatives of stopping and continuing a project which is underway will produce no go decisions for both alternatives. Under these conditions, the rule must be altered so as to choose the least unattractive alternative.

(ii) The replacemont decision: For a continuing project from time to time there appears the question of purchasing a replacement for present equipment. Such replacement may or may not involve a change in the technology utilized by the replacement equipment. Ideally, this type of problem can be studied in exactly the same way as any other investment. The flows of benefits and costs which are relevant are the increments in costs and benefits which arise from the replacement, above the costs and benefits expected in the absence of replacement. Given this information, one of the decision criteria can be utilized. No differences in principle exist. One well developed approach to replacement decisions for machinery which has been widely used in the United States is the so-called MAPI formula.[1/]

(iii) Mining industry: The mining industry has a special problem: it uses up a physical asset, namely, the ore in the mines. As such, the mine has a finite lifetime. Investments in mines are simply decisions on

---

1/ Terborgh, George, Dynamic Equipment Policy, New York: McGraw-Hill, 1949; Terborgh, George, Business Investment Policy: A MAPI Study and Manual, Washington, D. C.: Machinery and Allied Products Institute and Council for Technological Advancement, 1958.

different ways of doing the same thing, since the rate of extraction is a variable which can be chosen by the entrepreneur. However, once the extraction rate is chosen, no special depletion allowance is necessary in calculating the flow of net benefits from the project. The ore, which in some sense is not paid for but provided by nature, has a zero opportunity cost and the fact that it is used up brings no additional costs to the firm. Furthermore, the heavy exploration costs which characterize most mining should be treated as a sunk cost after they are made so that they affect the benefit flow only in so far as they affect the cash position of the enterprise.

(iv) Agricultural projects: Agricultural projects are characterized by an inability to distinguish sharply between capital costs and other costs. If the fertility of the land is destroyed by failure to use fertilizers and good conservation practices, the life of the project will be shortened, the yield of the land reduced, and the costs of the project reduced. For a given conservation program it is possible, in principle, to calculate the costs and benefits. Then any of the go-no go decision rules may be used to reach a decision.

(v) Foreign aid projects:[1/] The analysis of foreign aid projects is a straightforward application of the go-no go criteria. The interesting question is how one should view the availability of capital from foreign

---

1/ The procedures utilized by the Agency for International Development in project evaluation are described in United States Agency for International Development, 1963.

assistance organizations. There are two alternatives: (1) the foreign assistance is provided to the country and the application of these funds to specific projects is determined at some subsequent time; or (2) the foreign assistance is provided for a particular project and in the absence of the project the capital would not otherwise be available. In the latter case the size of the foreign aid allocation is dependent on the number of satisfactory projects available.

In the first case, in an imperfect capital market, the effect of foreign assistance is to lower the opportunity cost of capital, enabling more projects to be selected. In the case of a perfect capital market (i.e., a situation in which all projects which have a positive present value should be undertaken), the foreign assistance eases the saving burden on the domestic economy but does not affect the selection of projects. This situation is relevant for certain countries where foreign assistance is provided through consortium-type arrangements. The proper procedure in this case is to forget the distinction between domestic and foreign capital so that the initial capital costs include all of the costs regardless of origin and the recurrent costs in the future do not include any interest or principal repayments. These costs represent general costs to the economy in future periods and are not specific to the project.

In the second case the cost of capital provided from abroad does not count as a capital cost; rather, it is the repayments of principal and interest in future periods. (Of course, the project may not have to actually repay the loan, but that is not really the point.)

C. SELECTION CRITERIA FOR DIFFERENT WAYS OF DOING THE SAME THING

The problem of selecting between different ways of doing the same thing arises whenever one considers variants of a basic project. The variant may be quite different, for example, building a railroad rather than a road; or the variant may be quite similar, for example, a different location for the project. What is involved, however, is a collection of variants of the same basic project. Of these variants it is assumed that only one will be executed. It is very important in project selection to consider as many variants as is feasible, since it is sometimes far from obvious what constitutes the best way to do something.

The solution in principle is very simple. We ask which variant has the greatest present value. If, for example, there are two alternatives and all other projects have been selected, the one with the greater present value will raise the discounted consumption stream the most. The go-no go present value criterion (go if the present value is positive) is not relevant because we have imposed a constraint; namely, at most, one of the projects can be carried out.

Each variant of a project has a given lifetime, but these lifetimes may not all be the same. The differences in lifetime must somehow be taken into account. The procedure we suggest for doing this is as follows: We define two ways to extend the project. The first extension is to repeat the project whenever it terminates and continue such repetitions indefinitely into the future; the second extension is to assume the investment is repeated

but at a marginal rate of return given by the opportunity cost of capital at the time of the renewal of the project. Either of these procedures will extend the duration of the project indefinitely and enable us to compare projects with different lifetimes. These procedures appear to be rather complicated, but the basic idea is simple.

To show the difference between the two procedures, let us examine the present value of a project extended by repetitions of the project, $PV_1(\infty)$, and the present value of a project extended by reinvesting at the opportunity cost of capital, $PV_2(\infty)$. The simplest case is when the opportunity cost of capital is the same as the interest rate. Then the repetitions case is solved by noting the validity of the following relationship:

$$PV_1(\infty) = PV(T) + e^{-rT}PV_1(\infty)$$

where PV(T) is the present value of the project for its lifetime of T years. This relationship follows since the present value of an indefinite repetition of the project equals the present value of the first T years plus the present value of the infinite repetition of projects adjusted to take account of the fact the infinite stream of project repetitions starts out at time T. Solving the above equation gives:

$$PV_1(\infty) = \frac{PV(T)}{1-e^{-rT}}$$

This gives the correction required to determine the present value of the repetition of the project.

When the reinvestment is at the marginal rate of return, equal to the discount rate in the perfect capital market, the present value will be called:

$$PV_2(\infty) = PV(T) + e^{-rT}(-K + \frac{M}{V})$$

where K is the capital cost, M is the annual earnings of the investment K, r is the time preference rate. In a perfect capital market we have $+ K = \frac{M}{V}$ and

$$PV_2(\infty) = PV(T)$$

In comparing two projects we must decide if we wish to think of repetition of the project or simply a general investment after the lifetime of each project has expired. The first method is preferable if we think it is certain that the good or service provided by the project must be available into the indefinite future. If, however, we believe the project may not be continued, we would use the second method. The procedure is to determine PV (∞) for each project and then choose the larger.

When the capital markets are imperfect, then the situation is more complex. If the opportunity cost of capital is $\lambda \neq 1$ during the initial period but is equal to one thereafter,

$$PV_1(\infty) = - K + PV^1(T) + e^{-rT}(-K + PV^1(T)) + \ldots$$

where K is the initial period capital cost; $PV^1(T)$ is the present value omitting this initial period. It is easy to transform this into:

$$PV_1(\infty) = \lambda K + PV^1(T) + \frac{e^{-rT}}{1 - e^{-rT}} [-K + PV^1(T)]$$

$$= K(1 - \lambda) + \frac{-K + PV^1(T)}{1 - e^{-rT}}$$

(When $\lambda = 1$, this reduces to the previous case since $PV(T) = -K + PV^1(T)$.

In the second case we have the adjusted present value criterion,

$$PV_2(\infty) = -K + PV^1(T)$$

When the opportunity cost of the capital deviates from the interest rate in more than one period, then the general formula for $PV_1(\infty)$ is:

$$PV_1(\infty) = -\lambda_1 K + PV^1(T) + e^{-rT}[-\lambda_{T+1} K + PV^1(T)]$$

$$+ e^{-2rT}[-\lambda_{2T+1} K + PV^1(T)] + \ldots$$

For practical problems we can either assume the capital cost is equal to one, i.e., on an annual basis is equal to the time preference rate after the first period, or assume the first period opportunity cost holds in all periods. In the former case we have already given the answer; in the latter case we have

$$PV_1(\infty) = \frac{-\lambda K + PV^1(T)}{1 - e^{-rT}}$$

In the same way, $PV_2(\infty)$ would become:

$$PV_2(\infty) = -\lambda_1 K + PV^1(T) + e^{-rT}(-\lambda_{T+1} K + \frac{M}{V})$$

Now, however, we cannot be sure the final term will vanish. For all cases, specification of the capital market imperfections is essential to the formulation of the problem.

This method presented above essentially solves the problem of selecting between different ways of doing the same thing. The procedure is to calculate $PV_1(\infty)$ or $PV_2(\infty)$, the present value of investments of infinite life formed from repetitions of the initial project or by reinvestment at some specified rate of return. Which is relevant depends on the problem. Then a comparison is made between the present values of the variants. We will now discuss briefly some of the applications which may be made of this.

The Lutz Problem:[1/] What we call the Lutz problem is the classic investment problem: From a continuum of combinations of capital and labor, choose that which is best. That is, the firm is making an investment in an industry and it can choose among a wide range of techniques. The problem is to determine what is the right choice. The answer to this question is that the technique should be chosen which gives the highest present value. The discount rate used to determine the present value should be an introspective one which measures the desired rate of return (i.e., time preference) of the person (or society) making the judgment.

The internal rate of return: It is never right to use the internal rate of return in the study of exclusive projects.

1/ Lutz and Lutz, 1951.

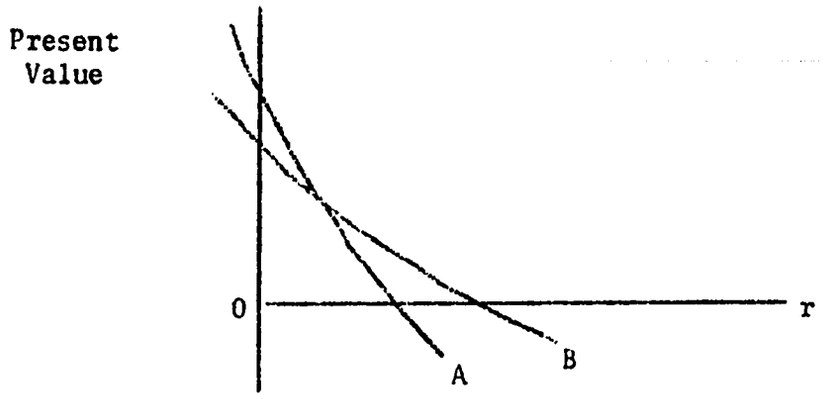

Figure 20

Examination of Figure 20 shows that the present value of A is greater than B for some interest rates, yet the internal rate of return of A is less than that of B.

Applications: There is a vast number of ways the variants of a project can appear, and we satisfy ourselves here with noting the more important ones.

First, alternative locations can be considered. There is considerable literature on industrial location problems, but it all comes down to the fact that transportation costs and factor endowments differ from region to region.[1/] In addition, the costs of urbanization are an important indirect cost.

Second, the size of the factory can vary. One can build larger than current demand and allow the market to increase or build a smaller plant initially and then expand. It is usually cheaper to build a single larger

---

1/ See Isard, W., Methods of Regional Analysis, New York: John Wiley, 1960.

plant initially, but the deferral of part of the capital cost may be sufficient to make the second course preferable.

Third, variations in technology are possible. In this case, it is factor costs which are decisive.

Fourth, the starting time of the project can be delayed; in this case the loss in net benefit from delay must be at least equalled by the gain from waiting.[1/]

The important thing for the planner to have in mind is that the study of project variants is a crucial part of good resource allocation. When working on a particular project, he should explore the alternatives quite carefully trying to find a better way to use the resources.

D. SELECTION CRITERIA UNDER CAPITAL BUDGETING

The previous discussion has treated each project as a separate decision which was compared, so to speak, with an abstract general alternative investment. This abstract alternative is described by certain parameters which are descriptive of the economy and which must be known to proceed with any of the go-no go criteria. The capital budgeting situation is somewhat different at first sight: There exists a large number of projects and a fixed supply of resources; which projects should be carried out? The

---

1/ Marglin, 1961.

literature on development planning has put a great deal of emphasis on this problem.[1/] The usual solution is reached by setting up an appropriate criterion for ranking the projects and then choosing the highest ranking projects until the available resources have been used up.

From the previous discussion it is clear that what we are trying to do is to choose the set of projects which satisfy the capital availability constraint and yet make the aggregate present value of the projects greatest. We begin by assuming that the discount rate (the social time preference) is known. We can then say we should choose projects which have the greatest present value not including the capital cost (assumed to fall due in the initial period) for each unit of invested capital. That is, we rank projects by the ratio PV_i^1/K_i, where PV_i^1 is the present value of the ith project leaving out the initial year and K_i is the capital cost (i.e., the resources used in the first year). The present value of the project is $-K_i + PV_i^1$. By taking the above ratio as the ranking criteria we determine an order for the projects and, as pointed out above, we proceed by choosing projects until we run out of resources available for investment. This solves the capital budgeting problem.

How is it related to the go-no go criterion? First, if the capital being allocated is just that amount which would be made available in a perfect capital market, the go-no go criterion would choose every project

---

1/ Chenery, 1953.

with a positive present value. The capital budgeting solution would always rank a project with a positive present value in such a way that it would be chosen. The capital budgeting solution would always rank a project with a positive present value higher than one with a negative present value; consequently, the same group of projects would be chosen. The worst project chosen by the capital budgeting rule would have a present value close to zero corresponding to the ranking criterion close to one. If the available capital does not correspond to that which would be invested in a perfect capital market, the the go-no go rule is to choose projects for which $PV_i^1 - \lambda K_i$ is positive, where λ is the opportunity cost of capital. How should the opportunity cost of capital be calculated? One simply ranks projects by the ratio PV_i^1/K_i and then chooses λ so that the worst project accepted under the budget constraint has a ranking ratio λ. Then the go-no go decision rule criterion would have a value of zero for the worst project just as we would like. When $\lambda = 1$, the capital available is just equal to the amount invested in a perfect capital market.

We can now ask how the ranking provided by the other criteria work. Since we have proved previously that when there is a perfect capital market most of the criteria gave the same answer, we would expect this to be true in the case of the capital budgeting problem. In fact, the ranking of projects may not be the same, but the projects selected will be. This is another manifestation of the operation of the system when there is no difference between the opportunity cost of capital and the social time preference rate (remembering to express them both in annual terms with the formula $r_{OC} = \lambda r_{TP}$

where r_{OC} is the opportunity cost of capital, as previously defined, expressed as a per cent, and r_{TP} is the social time preference). Problems appear only when there is a difference between r_{OC} and r_{TP}; that is, when the capital market is imperfect.

There is another view widespread in the literature which seems to us incorrect.[1/] The procedure is to guess at a discount rate; rank the projects by the ratio PV_i^1/K_i where the guessed discount rate is used in the present value calculation; then the ranking ratio of the marginal project is determined, and the discount rate is changed if this is different from one (raised if it is greater than one and lowered if it is less). The procedure is repeated until the discount rate is found which makes the ranking ratio of the marginal project one. Then this sets the projects to be chosen. The resulting interest rate is what the above authors call the opportunity cost of capital. The same result can be achieved using the internal rates of return to rank the projects, but now no recursive steps are needed. The opportunity cost of capital is defined as the rate of return on the marginal projects. It is obviously much easier to use the internal rate of return ranking; this is one of the reasons the internal rate of return is so popular. However, if the time preference rate and the rate of return on the marginal project are the same, then the capital market is perfect. Consequently, if the capital market is perfect but the time

---

1/ For this, see Marglin, February, 1963, May, 1963; McKean, 1958; Hershleifer et al, 1960.

preference rate is not known, ranking by the internal rate of return is the most efficient way of proceeding and the time preference is determined from the rate of return on the marginal project. But when the capital market is imperfect, the distinction between the two rates becomes critical. For this reason it seems more satisfactory not to use the internal rate of return which is so often suggested as a ranking criterion.

The capital budgeting problem can formally be stated as an integer programming problem.[1/] This enables one to attack problems where the lumpiness of projects causes the ordering of the projects to give a non-optimal solution. More important for the planning problem, it shows how to take account of capital budgeting for several years rather than one; or, more generally, it enables us to solve problems where there are constraints other than for capital. Although this is clear enough conceptually, it is unlikely that programming techniques will be usable within the context of the less developed countries. However, as Baumol and Quandt[2/] emphasize, the formulation of the problem in programming terms clears up many of the conceptual difficulties.

In conclusion, the capital budgeting problem is relevant for our purposes because it enables the planner to calculate the opportunity costs within imperfect markets. In actual operations such opportunity costs may be

---

1/ Weingartner, H. Martin, Mathematical Programming and the Analysis of Capital Budgeting Program. Englewood Cliffs, N. J.: Prentice-Hall, 1963.

2/ Baumol, W. J. and Quandt, R. E., "Investment and Discount Rates Under Capital Rationing--A Programming Approach," The Economic Journal, Vol. LXXV, No. 298 (June, 1965), pp. 317-329.

established by reference to the previous year (an approximation) or by explicit ranking of available projects. There is no question but that the concept of capital budgeting is useful for the planner to keep in mind, but its applicability is not easy. It should also be noted that if we are using a rule of maximizing employment, say, with a fixed capital availability, the employment per unit of capital becomes the relevant ranking criterion.

E. FURTHER PROBLEMS OF SELECTION CRITERIA

In this section two problems of selection criteria, interdependencies and uncertainty, will be discussed. These problems inject themselves into project analysis regardless of the type of decision to be made. Unfortunately, while their importance is well recognized, neither problem has been solved in practical terms. Some conclusions can be drawn at the theoretical level, but it still remains to translate them into operational guidance.

1. Interdependencies

(a) Three types of interdependencies

Three crucial types of interdependence can be identified in the literature: First, there are interdependencies between the projects in a particular project universe; that is, the project universe at a particular point in time. This is the ordinary concept of interdependence. There may be many ways projects are interdependent: e.g., there may be mutually

exclusive projects; or, projects for which the benefits or costs depend on whether another project is done; in an extreme form, the decision not to carry out a project may block another project.

Second, there may be direct interdependencies between projects in different universes. That is, whether a project is done this year may influence the return to a project which is under consideration for a later time. This is the linkage concept stressed so much by Hirschman.[1/]

Third, projects selected now may influence future factor supplies. This is the point which Galenson and Leibenstein[2/] make. Their argument launched what is perhaps the most destructive attack in the literature on present value and similar criteria. Their point is this: If capital markets are imperfect, projects selected in the first period affect future savings. Therefore, they argued, the conventional criterion is not valid. This point is correct, but what is not known is how strong such effects might be. When choices between projects are being carried out, neglect of this saving effect will bias projects towards those in which less saving is done from income payments. For example, if saving from profits is greater than saving from wages, then a higher capital intensity might be desirable to that called for by the conventional SMP, or present value criterion.

1/ Hirschman, A. O., 1958.

2/ Galenson, W., and Leibenstein, H., "Investment Criteria, Productivity and Economic Development," The Quarterly Journal of Economics, Volume LXIX, No. 3 (August, 1955), pp. 343-370.

Eckstein[1/] has developed a method which corrects for some capital market imperfections. The procedure is to calculate the opportunity cost of capital in the first period by determining the effect of the project on the future supply of saving. Both direct and indirect saving are taken into account. This leads to the development of the marginal growth criterion which makes the opportunity cost of capital different from the marginal productivity of capital. Since Eckstein does not include capital constraints in any period but the first, it is not obvious how this method of causing a difference to arise between opportunity cost and marginal productivity should be understood. Within our framework the opportunity cost of capital for each relevant period must be determined, taking into account the Galenson-Leibenstein viewpoint if it is relevant, and the opportunity costs will affect a project started now so long as that project affects the supply of funds under constraint. But for any period the opportunity cost of capital is the same as the marginal product of capital. Eckstein shifts these future consequences of the project back to the present in a way which approximates the true solution.

The Galenson-Leibenstein point was generalized by them to include other similar problems. All projects, they would argue, affect future supplies of skilled and unskilled labor. In our terminology, there are class two effects from the project. Skilled manpower, it is argued, will be

---

1/ Eckstein, 1957.

greater in the future if projects are selected now which have the effect of providing "on the job" training. Since this is likely to be connected with modern, capital-intensive projects, this argument also indicates a shift away from the present value selected projects. In the same way, the supply of unskilled labor may be affected since the distribution of income arising from the project may change the rate of growth of population.[1/]

The point of the Galenson-Leibenstein argument is that there are interdependencies between projects through the indirect mechanism of changing future factor supplies. These indirect effects were explicitly excluded in earlier discussion to justify the use of the present value criterion. Furthermore, these effects rest on imperfections in both the capital market and in the ability of the government to allocate resources to population control and education. Since these failures in the fiscal system's ability to raise resources and in the resource allocation mechanisms of the economy are thought to be widespread in less developed countries, the critique by Galenson-Leibenstein is very powerful. Despite the effort by Eckstein, there is at present no satisfactory criterion which takes into account these interdependencies through changing factor supplies.

The question of the empirical validity of the connection between capital intensity or size and profits has been the subject of some empirical work. The evidence seems to indicate that there is no necessary

---

1/ This point is further discussed in Ranis, G., "Allocation Criteria and Population Growth," The American Economic Review, Volume LIII, No. 2 (May, 1963), pp. 619-633.

correlation between capital intensity and profits and; hence, if there is a higher propensity to save out of profits than out of wages, it does not follow that the greater the capital intensity of the projects, the more future saving will increase.[1/] It should be noted that the Galenson-Leibenstein argument has two parts: First, that there are interdependencies which operate through future factor supplies (and in their case for saving, skilled manpower, and unskilled manpower); second, the effect of these interdependencies is to enhance the attractiveness of capital-intensive projects which raise saving, increase the training of skilled manpower, and reduce population growth. Ranis has attacked the second part of the argument. Putting aside this empirical question, the first part of the argument indicates there may be serious problems with currently used selection criteria <u>if</u> the interdependencies emphasized by Galenson-Leibenstein are important. This last empirical point is the critical one and has yet to be thoroughly explored.

(b) The programming approach to interdependencies

One obvious answer to the problem of interdependencies is simply to try out all combinations of projects. That is not a very interesting prescription, and one would like a procedure for shortening the search for the optimum. Little work has been done on this yet, since it leads into

---

1/ Ranis, G., "Investment Criteria, Productivity and Economic Development: An Empirical Comment," <u>The Quarterly Journal of Economics</u>, Volume LXXVI, No. 2 (May, 1962), pp. 108-135.

non-linear integer programming problems about which little is presently known.[1/] The programming framework is a useful one within which to study this problem, but applications to development problems await further research.

Notice that interdependencies occur when one project specifically affects another project or when one group of projects will have a different effect from another group on a specific project. Of course, there are always interdependencies; the crucial question is how important are they. It is ironic and a bit unsettling that the central concepts of growth theory, as reflected in the big push, and the balanced and unbalanced growth arguments all emphasize the importance of interdependence, and yet the basic intellectual apparatus of capital theory cannot handle the problem.[2/]

One type of interdependence important in social overhead investments is the project which induces more projects. Roads are an example. If the induced investment is sure to take place when the project is undertaken, the analysis of the original project should include the costs and benefits of the induced project. One must be careful to include capital costs valued at an opportunity cost which may be different for the original project and the induced investment. If the induced investment is not a sure thing, two different but exclusive projects should be studied, one the original project

---

1/ Weingartner, 1963, discusses linear cases; Reiter discusses non-linear cases of a rather limited type: Reiter, S., "Choosing an Investment Program Among Interdependent Projects," The Review of Economic Studies, Vol. XXX, No. 1 (February, 1963), pp. 32-36; Reiter, S. and Sherman, G. R., "Allocating Indivisible Resources Affording External Economies or Diseconomies," International Economic Review, Vol. 3, No. 1 (January, 1962), pp. 108-35.

2/ Rosenstein-Rodan, 1943; Rosenstein-Rodan, P. N., "Notes on the Theory of the Big Push," in Ellis, H. S. (ed.), Economic Development for Latin America, New York: St. Martin's Press, 1961.

without the induced project and the other, the original with the induced project.

In conclusion, the problem of interdependencies is crucial, both in the eyes of practical men and theorists, but to date little is understood about methods for dealing with the problem apart from exhausting all combinations. This is probably the largest hole in the conceptual wall. If it is the case that interdependencies are important, the whole pattern of investment arising from present value calculations may be incorrect.

2. Uncertainty

The information that project planners use inevitably contains some ignorance. Anyone involved in the analysis of projects is aware of the highly tentative nature of much of the data that goes into the determination of costs and benefits. The problem with which we deal in this section is how such uncertainty can be handled. There are several sources of uncertainty but, before examining them, it will be helpful to consider how uncertainty can be incorporated into the utility function.

(a) Uncertainty and utility

In the previous discussion of the utility function, the argument revolved around welfare which accrued to the individual because commodities were consumed. Implicitly it was assumed that the commodities chosen by the consumer would, in fact, be consumed. There was no concept of risk. If there is risk that the quantities consumed may be different from their

expected levels, a more complicated analysis is necessary. This problem is analyzed within the framework of a utility function which depends on consumption and risk. The consumer will be presented not with choices between exactly known consumption values, but with choices between sets of possible values of consumption. In choosing a particular set for a given time period, the consumer knows that only one of the set will actually materialize. He will choose a particular set on the basis of the probability which each outcome in the set has. Given the probability distribution for each possible set of consumption values and, given the relationship between consumption and utility, it is conceptually straightforward to determine the probability distribution of the utility which arises from the choice of any particular course of action. From this utility probability distribution one can determine the expected utility and some measure of the risk of deviation from this expected level. Two possible measures of risk are the variance of the distribution and the probability of the utility falling below some absolute level. Each possible pattern of action determines an expected utility and some measure of the risk attached to it. Then the consumer must choose that combination of risk and expected utility which seems to him the best. In general, one would expect that the higher the expected level of utility, the greater would be the risk. This situation is shown in Figure 21. The mean of the distribution, μ, is the expected utility level for any particular distribution of possible consumption, and the variance of the distribution, σ^2, is used as the measure of risk.

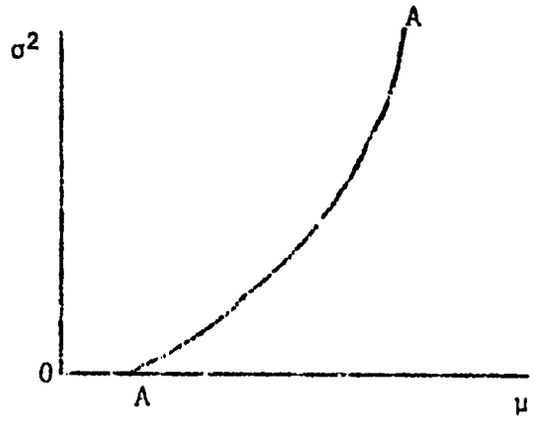

Figure 21

Each point on the AA curve represents a different consumption bundle. The curve AA is drawn to show that to increase expected utility, one must accept greater risks. It represents the boundary of combinations of risk and utility, since it should be possible to choose other combinations of expected utility and risk which lie above and to the left of AA. Most individuals would presumably choose to be on AA rather than to the northwest of it, since when one is off the curve, it would be possible to reach the same expected utility at a lower risk.

Indifference curves can be added to this diagram that show which combinations of risks and expected utilities the consumer is indifferent to. A typical set of indifference curves is shown in Figure 22. For risk-utility combinations to which an individual would be indifferent, expected utility would have to increase as risk increases. Hence, the indifference curves slope up to the right. In Figure 22 the indifference curves have been drawn in such a way that the indifference curves become flatter as the expected utility increases. Such indifference curves would represent a risk averter

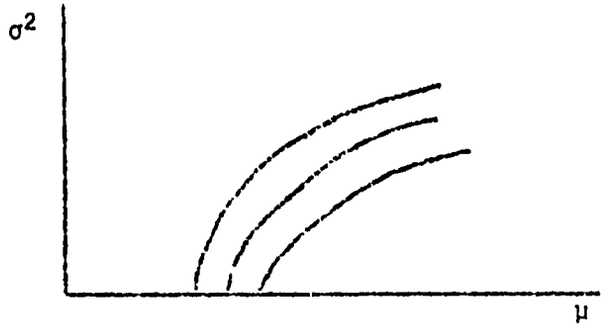

Figure 22

who must be "paid" increasingly large amounts of expected utility to induce him to accept more risk. It is also possible that a person may be a risk acceptor. For risk acceptors, the indifference curves become steeper; that is, the person will accept a higher risk for a chance at a greater expected return. Figure 23 has been drawn with a risk acceptance region (below the dotted line) and a risk avoidance region (above the dotted line).

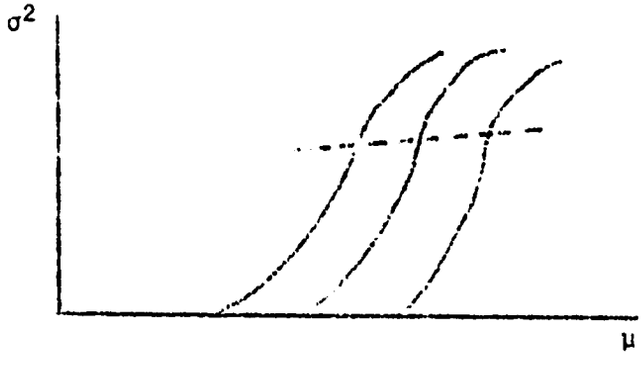

Figure 23

Whatever the shape of the indifference curves, the optimal course of action is found by combining the alternative risk-expected utility choices with the preference system. This is illustrated in Figure 24.

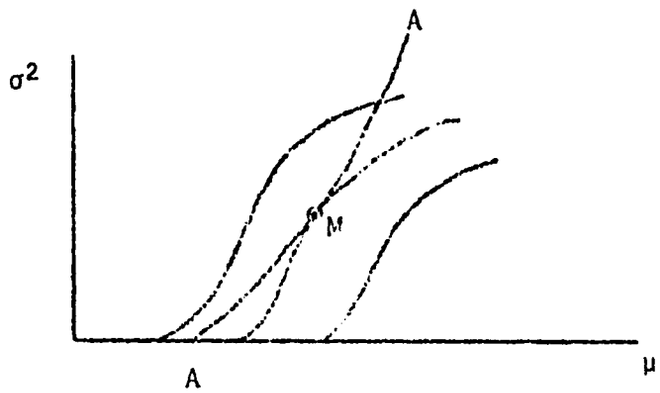

Figure 24

The individual will choose the combination of expected utility and risk represented by M, the point of tangency of an indifference curve, and AA. This point gives the highest indifference curve that the individual can reach within the region whose boundary is AA; i.e., the region of possible choice.

The use of a preference system here is simply an extension of the sort of preference system discussed earlier in this paper. In the earlier discussion, preferences were used only to explain choices between alternatives involving expected levels of utility. In the present discussion, preferences between risk and expected utility have been added. Whenever there is uncertainty in a situation, the risk characteristics of the preference system become relevant.

(b) The three project selection problems with uncertainty present

We can now illustrate the application of a preference system with risk dimensions to a project selection problem. Suppose one has a project which has some uncertainty attached to the outcome of the project. Thus, there are probabilities for various levels of the present value of the project, with both positive and negative values possible. Given this information, the expected present value of the project and some measure of the risk involved in it can be determined. If a whole collection of projects is to be considered, it would be possible to determine for each different combination of projects the expected present value and some measure of the risk. The set of alternatives then is analogous to the region northwest of the AA line in Figure 21, where the expected present value takes the place of the expected utility. In the absence of uncertainty all projects which have positive present values would be chosen or, where combinations are to be considered, the bundle of projects which has the maximum present value would be chosen. When uncertainty is introduced, however, the situation changes and one may wish to accept a lower expected present value in order to reduce the associated risk. Thus, conceptually, the capital budgeting problem is solved.

The go-no go problem is formulated in an obvious way: The decision rule is to proceed with a project if its expected present value exceeds some specified level and the risk associated with the project is less than some specified risk. In the capital budgeting problem the solution picks

some bundle of projects. This bundle defines a region in the σ^2, μ space of Figure 21. If it was known in advance just where this region was located, the decision rule would be to ask for any single project if its σ^2 and μ were in the region. The go-no go decision is much more complicated in the uncertainty case simply because we no longer have a simple maximization procedure.[1/]

The choice between alternative projects to accomplish the same purpose is similarly defined by asking which of the alternative risk-return combinations is preferred. All three of the project planning problems are thus extended, at the conceptual level, to include uncertainty.

It should be noted in passing that if one were completely neutral to risk, the expected present value is all that is relevant to project selection; the risk measure associated with the project turns out to be irrelevant. With neutrality towards risk, the problem is the same as if the expected present value were certain. However, if one is not neutral towards risk, the project selection problem must be developed with explicit recognition of the riskiness as was done in the preceding paragraphs.[2/]

The presentation above requires knowledge of the risk preferences of the project selector. Lacking full information on preferences, one way to simplify the problem would be to specify a target expected present value

---

1/ This point is further discussed on Cookson "Notes."

2/ The above discussion is based on: Masse, 1962; Dryden, 1964; Lutz and Lutz, 1951; Hershleifer, J., "Efficient Allocation of Capital in an Uncertain World," The American Economic Review, Vol. LIV, No. 3 (May, 1964), pp. 77-85.

and then minimize the risk. Alternatively, one could specify a level of risk and then maximize the expected present value. The former problem is represented graphically in Figure 25. The set of projects which will have

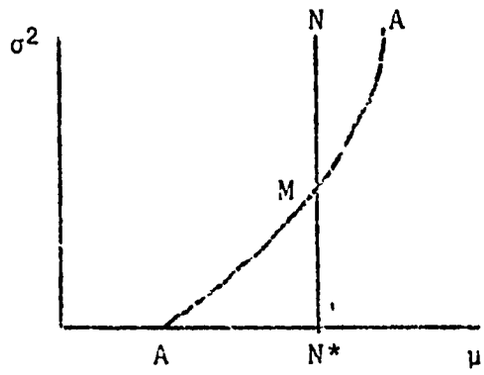

Figure 25

an expected present value of N* (specified) is given by the line NM. The minimum risk is found at M, where this line cuts the boundary of the alternative project bundles. Similarly, if the risk is specified, a horizontal line would give the alternatives with the desired risk properties.[1/]

(c) Sources of uncertainty

Next we turn to the ways uncertainty can appear. Three uncertainty sources can usefully be distinguished. First, there may be ignorance about the benefits and costs associated with the project; second, there may be

---

1/ Markowitz, Harry, Portfolio Selection: Efficient Diversification of Investments, New York: John Wiley, 1958.

inherent stochastic or random chance elements; third, there may be non-stochastic uncertainty arising from conflict situations. Of course, combinations of the three can also be present.

The uncertainty arising from ignorance can be further broken down to cases where the ignorance about benefits and costs has known stochastic properties and cases where no such information is available. In the former case, the problem is logically the same as those where there are stochastic elements of the project itself. If, however, nothing is known of the stochastic nature of the project or of the information about the project, the problem is much more difficult. In fact, conceptually there is no way to proceed without the construction of some kind of probabilities of the outcome. The basic viewpoint of the Bayesian is relevant here: One can always construct a probabilistic structure around any uncertain situation by studying how the decision maker views the problem. In a sense, this enables one to turn any problem into a problem to be approached as those in the second category are approached. However, this really begs the question: One is trying to make sensible decisions given attitudes about risk and any probabilistic information should come from outside the mind of the decision maker.[1/]

1/ See Schleifer, R., Probability and Statistics for Business Decisions, New York: McGraw-Hill, 1959; Raiffa and Schleifer, R., Applied Statistical Decision Theory, Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1961; Savage, L. J., The Foundations of Statistics, New York: Wiley, 1954.

If the Bayesian approach is unacceptable, when one is ignorant, there is little that can be done except to attempt to reduce the degree of ignorance. The best procedure is to try to establish limits to the factors about which there is ignorance. Then the relevant decision rule is applied. If the choice is clear-cut, regardless of the limits, there is no problem. If, however, the decision chosen is reversed according to which set of limits is chosen, further analysis is required to make a suitable choice.

It should be noted that simply making conservative assumptions is not appropriate in choosing between alternatives. To make conservative assumptions about projects misses the whole point of choosing between alternatives.

The second type of uncertainty involves an inherent stochastic or random element in the project. This situation is the one which underlies the risk vs. expected utility presentation above. It is an important one in development planning and occurs repeatedly. For example, all demand forecasts based on statistical analysis fall into this category. Projects where the weather has an effect on benefits and costs also fall into this category. Water resource projects where the stream flow depends on precipitation are an example.[1/] All agricultural projects where yields depend on random weather factors are another. Complex projects involving many

---

1/ Eckstein, O., Public Finance, 1961; Masse, 1962.

stochastic components can be analyzed to give probability distributions of overall returns or costs. Where time is a measure of returns or costs, the PERT and CPM techniques provide exactly this kind of information.[1/] For projects which fall in this category one would establish the expected present value and the measure of risk (say, the probability of a negative present value) and then proceed as previously discussed. To do so, of course, requires specific information on the probabilistic nature of the project. Without this information, one is back to the first category of project uncertainty.

The third and final category of uncertainty arises when there is no stochastic structure to the project, but the outcome depends on unknown decisions of persons outside the planning process. This is the situation which arises in all decision problems involving conflict.[2/] To some extent this may describe the planning problem in the development of export industries. If everyone tries to grow coffee, everyone will be ruined. Much of the desire for international commodity agreements and for the creation of an orderly institutional framework for export development reflects the difficulties of making decisions for this type of problem. The approach of the game theorist is applicable here, but in actual problems it is virtually impossible to make any headway. The instinctive reaction of the decision maker to try to negotiate away the uncertainty is probably as sound as any other line of action.

1/ Keller, R. W., Schedule, Cost and Profit Control with PERT, New York: McGraw-Hill, 1963.

2/ See Luce, R. O. and Raiffa, H., Games and Decisions: Introduction and Critical Survey.

(d) Commonly used means of handling uncertainty in project analysis

The discussion of uncertainty in project analysis presented above has been carried on largely at the conceptual level. In actual practice the problem is apt to be handled with rather crude devices. Practical methods of adjusting for uncertainty can be summarized as follows: (1) Raising the discount rate in present value calculations. This is not good procedure since it distorts the basic meaning of a present value calculation. (2) Making conservative estimates of benefits and costs; i.e., making a low benefit estimate and a high cost estimate. This may serve reasonably well for go-no go decisions but distorts choice between alternatives. (3) Adding contingency allowances in the capital cost estimate. This is an important method of adjusting estimates made by project evaluations. It is often found that actual costs run 10-25% above project cost estimates.[1/] It is, therefore, a good idea to include such a contingency allowance in the project. This is really an ignorance reducing measure rather than a method of adjusting for uncertainty.

In conclusion, the three ways uncertainty can enter into project planning have been very briefly surveyed. It was found that there is a satisfactory conceptual solution when the uncertainty has a stochastic structure which can be specified. When the project planner is simply

---

1/ See, for example, Healey, J. M., "Errors in Project Cost Estimates," The Indian Economic Journal, Vol. XII, No. 1 (July-September, 1964), pp. 44-52.

ignorant, he must determine if the ignorance is relevant to the decision problem and, if so, attempt to reduce it. If the present value of the project is determined by a conflict-type situation, then it is appropriate to turn to agreement with the other parties to reduce the uncertainty.

F. FEASIBILITY

The concept of "feasibility" is central to project selection decisions. By feasibility we mean the criteria other than those related to the straight economics of a project by which some organization or person concerned with the project decides to proceed with it. It should be clear that feasibility is a concept specific to each decision maker concerned with a project. In development planning the government is the representative of the public interest and not only has its own concept of the feasibility of the project but by its actions can influence the feasibility as seen by other persons concerned with it.

In fact, feasibility means several things, and it is worth being clear about the differences. The engineering feasibility depends on the conclusion that the technology of the project will work. The extent of engineering studies required to determine feasibility will vary substantially with the type of project. It is self-evident that the more radical the technology, the more care must be taken with the determination of feasibility. When local raw materials are to be used or when the project may be strongly affected by local conditions, then once again care must be taken with engineering feasibility. It is important to note, though, that

there are usually several alternatives which pass this test. All parties concerned with the financial and economic effects of the projects are interested in this determination of engineering feasibility. Until this is established, the project cannot be further considered.

The second important concept of feasibility is manpower feasibility. That is, are there men available for the project and, if not, can they be obtained? The range of specialized manpower reaches from the management down through the workers with specialized skills. The manpower program will affect the financial and economic feasibility of the project. Since several alternative manpower programs may be feasible, the choice between them comes from consideration of their effect on costs and benefits. This exactly parallels the feasibility of alternative engineering approaches. This viewpoint enables the project planner to incorporate directly into the project analysis additional costs associated with training local personnel. Differences in the value of a project to a country arising from differences in the mix of foreign and domestic employees can also be incorporated into the analysis.

A project must have demonstrated its engineering and manpower feasibility before one can begin to study its financial and economic feasibility. The financial feasibility must be judged by each private party to the project. The private entrepreneur must be convinced the project will earn enough to justify the investment. The private bank must assure itself that the private businessman will be able to repay a loan. Remembering that the financial feasibility is dependent on the policies followed by the government, changes in such policies can affect the financial feasibility as recorded by private persons.

For public sector projects financial feasibility means the capacity of the project to pay for itself. There may be projects which do not pay for themselves but which the government subsidizes because the economy benefits sufficiently indirectly from the projects to justify the subsidy. The question whether subsidy of projects by the government is good practice is not easily answered. From the economists' viewpoint, there may well be circumstances where this is good public policy, but the extent of subsidy in the economy must be judged both against a background of the overall position of the government budget and the quality of management available to insure that subsidized projects operate as efficiently as they can.

Economic feasibility has meaning only to organizations not responsive to market considerations. Usually this means the government and the public international capital sources. One should carefully distinguish between their views of economic feasibility. For the national government the economic feasibility is determined by the comparison of the costs and benefits to the economy of carrying through a project. The foreign public capital source is usually concerned with the economic feasibility of the total investment rather than that part of the investment which arises from the recipient country. In a sense, the foreign public capital source is interested in the optimum world allocation of capital and so is concerned with the economic feasibility of all of the investment.

Thus, in go-no go decision making, a project passes through a series of decisions: First, the engineering and manpower feasibility, then financial approval by all private persons involved, and finally economic feasibility from the viewpoint of the national government and perhaps an assistance-providing organization. Once this formidable list of hurdles is overcome, we may call the project feasible. Feasibility is the state of a project which is associated with a go-no go type of decision. Problems arising from a multiplicity of feasible projects are dealt with in subsequent sections.

Clearly, the determination of feasibility can be a rather expensive process, requiring detailed engineering and economic surveys. It is utopian to expect complete information on all projects under consideration. Furthermore, engineering feasibility is not always a clear-cut concept, since it refers to a given level of technology; new discoveries may indeed change the engineering feasibility of a project. In fact, in operational problems, the most important purpose of the feasibility study is to find methods of adapting a technical process to the local conditions. Good engineers can tell relatively quickly if the project will be feasible; after this initial screening the critical projects are then subjected to much more intensive engineering and economic studies. These expensive detailed studies should obviously be undertaken when there is reasonable assurance that the project will turn out to be a good one.

It is worth repeating that the feasibility of a project from the private viewpoint depends on the policies of the government towards the private sector. It is usually possible by the creation of sufficient incentives to induce the private businessman to take part in a project. However, if the income distribution is a matter of public policy, then the situation is more complex; there may exist no way to distribute the gains from the project so as to maintain what is considered a reasonable income distribution and at the same time to induce private sector interest. Only the acquisition of a considerable body of experience within a particular environment will enable the planner to assess the extent to which inducements are necessary to draw the private entrepreneur into participation in a project.

VI. THE INSTITUTIONAL SETTING OF PROJECT PLANNING

In this part the institutional setting of project planning is considered. First, an idealized planning system is examined. This system is that which reflects the sort of planning undertaken in non-centrally planned economies. However, many of the administrative organizations discussed have their analogs in centrally-planned economies, and many of the administrative problems are similar.

A. THE ADMINISTRATIVE ENVIRONMENT

To appreciate the real, operational problems of project evaluation one must be aware of the various factors which affect decision making within a government. In discussing this subject, it is useful to begin by defining some idealized administrative organizations and their roles in the development progress. There is no necessary correspondence between these ideal organizations and actual organizations. Then we discuss the actual situations that seem to prevail in many underdeveloped countries and the conflicts and problems that confront the project planner. We then briefly examine, in this framework, the purely competitive investment situation, the total planning situation and the intermediate situation of partial planning. Finally, we discuss the direction in which we feel project planning should move in order to improve the present situation.

1. Definitions

(a) The political authority

The political authority is the highest level decision-making unit in the government. This may be the Office of the President or the Cabinet, depending on the form of government. The political authority may choose to make a decision on an issue confronting the country; it may defer the decision for future consideration; or it may delegate the authority to a lower echelon in the government. The proper role of the political authority is to reflect a consensus of the nation; thus, the important choices that are made by the government of a country in principle reflects this consensus.

(b) The planning agency

The planning agency is a group of technicians whose task is to assist the political authority by providing technical guidance on decisions dealing with problems of economic development. The role of the planning agency can be summarized as (1) advising on those policy actions and decisions of the government which affect growth and (2) coordinating public expenditure programs. In this study of project planning we have been only concerned with this latter coordinating function of the planning agency.

(c) Expenditure control organization

The expenditure control organization is concerned with allocating actual funds for expenditure and insuring that expenditures are proceeding at the planned rate and for the proper purposes. If the first task is essentially automatic approval of funds for projects selected for implementation. The expenditure control organization is concerned largely with reporting on the process of implementation of decisions to spend public funds. Although the expenditure control organization is not directly concerned with expenditure, the implementation process, which it oversees, may have important consequences for future expenditure decisions.

(d) The ministries

The ministries are the operating agencies responsible to the political authority for carrying out projects and policies decided on by one of the methods mentioned in (a) whereby decisions are made. Within the ministries are planning sections whose task is to prepare plans for projects which the ministry believes may be worth executing and which fall within the province of the ministry. The ministry either forwards such projects to the planning agency for final approval of the project or utilizes selection criteria laid down by the planning agency to choose projects.

(e) Public enterprises

This represents the group of government-owned production facilities which are operated independently of the ministries. This may include such organizations as airlines, petroleum companies, heavy industry, power plants, water works, etc. Ideally, the public enterprise also has a planning unit which prepares projects on desired investments to expand the production facilities. Ideally, those projects are also forwarded to the planning agency for approval, or criteria specified by the planning agency are used for making choices.

(f) Private firms

These organizations are owned by private individuals, either nationals or foreigners, and some of them may choose to make investments. For some such private investments, firms may apply to the planning agency (or its agent) for special privileges designed to enhance the profitability of the investment. The planning agency (or its agent) guides the development of the private sector by the way in which such privileges are granted.

(g) Foreign assistance sources

Foreign assistance sources typically provide funds to cover part of the capital cost of some projects.

2. Ideal Planning Process[1/]

The ideal planning process begins with the planning agency making an aggregative projection of the economy. This forecast should include all components of gross domestic product. The results of this aggregate projection provide a basic framework of the economy for use by those concerned with project planning. The information developed in the planning agency in the aggregative planning process is useful both for demand forecasts and in determining the opportunity costs of factors of production.

Three groups are concerned with preparing projects: The ministry planning sections; the public enterprises; and private firms. In the ideal process projects from the first two will be submitted to the planning agency. Private firms wishing special privileges will also submit requests to the appropriate organization. This latter organization will grant approval of special privileges when this is consistent with the objectives of the aggregative plan.

The planning agency studies the new projects submitted to it, as well as the status of projects under construction as established by the expenditure control organization, and provides technical guidance to the

---

1/ For descriptions of ideal planning processes, see: Tinbergen, J., 1956; Marglin, S. A., Approaches to Dynamic Investment Planning, Amsterdam: North Holland Publishing Company, 1963; Tinbergen, J., 1958; United Nations Economic Commission for Asia and the Far East, 1960.

political authority as to what new projects should be approved and adjustments which might be made in projects already under way. The process of sorting out the investment proposals will be one of the major themes discussed later. Having selected projects from the viewpoint of the benefit to the national economy, the foreign assistance donors are brought in so that they can choose from the selected projects those which they wish to finance; this, in turn, enables more projects to be selected for financing from available domestic resources. The planning agency must then insure that the projects chosen are, in the aggregate, consistent with the assumptions of the aggregative projection. If the assumptions are inconsistent, they must be changed to conform with the implications of the projects (or vice versa), and then another round of project preparation and selection follows. (The demand forecasts and opportunity costs may have changed so that all projects now have different expected benefits and costs, and the bundle of selected projects may change.) The second round of selected projects is then checked for consistency with the aggregative assumptions. It is usually assumed that this process converges in the sense that we can find some set of projects which is consistent with the aggregative assumptions and maximizes the increase in national product.

The private sector presents no conceptual problems in this ideal planning approach. To the extent the planning agency has control over most of the private investment through licensing, import permits, tax exemptions, etc., private investment can be handled by simply treating such project proposals in the same manner as proposals from the public

sector. But if there is substantial non-controlled private investment, the planning agency must forecast the level of non-controlled private investment in the process of making its aggregative projection of the economy and, in so doing, will automatically examine the effect of alternative growth paths on non-controlled private investment. Thus, the aggregative analysis becomes much more complex, but the recursive nature of planning is still of foremost importance in the selection of public expenditure projects and controlled private investment projects.

The adjustment of the economy to an optimum through successive approximations has been intensively studied for simple exchange within a market clearing framework, but rather less is known about this problem when investment and growth are involved.[1/] In one extreme case where the aggregative forecast is made and all investment is non-controlled (in the above sense of no government approval required), the question has been asked: How can one be sure that, if the forecast is believed and used in the investment decision-making process by the firm, that the resulting investment will generate the growth originally forecast? This is an extreme case since government investment decisions are not part of the framework. The search for self-validating forecasting methods is important for

---

1/ For a highly technical discussion, see Arrow, Kenneth J., and Hurwicz, Leonid, "Decentralization and Computation in Resource Allocation," in Spoutz, Ralph W., (ed.), Essays in Economics and Econometrics, Chapel Hill: University of North Carolina Press, n.d.; also Marglin, S., 1963. The subject is implicit in earlier literature on the workability of socialism as an economic system; for example, see various papers in Lippincott, B., (ed.), On the Economic Theory of Socialism, Minneapolis: University of Minnesota Press, 1938, especially Lange, O., "On the Economic Theory of Socialism"; also, Lerner, 1944.

economies which wish to plan and yet promote a large private sector over whose investment decisions the government has relatively little control. This is, however, a field of work in which little seems to be known that is relevant to the project selection problem.[1/]

The essential aspects of the ideal planning process are: (1) centralized decision making; (2) recursive planning; (3) comprehensiveness of the role of the planning agency; and (4) independence of the foreign assistance activities from the problem of choosing among projects. Clearly this ideal process requires extensive data and cooperation between the planning agency and other parts of the government. The gap between this ideal and the actual will be discussed in the following section.

In the context of the ideal planning process it becomes the task of the ministry planner to identify the potential projects (Step 1). The valuation of the benefits and costs (Step 2) is also carried out at the ministry level, but it must rely on essential information developed by the planning agency. Finally, selection (Step 3) is carried out by the Planning Agency, given the set of projects developed by the ministries. The recursive nature of planning implies that this process may have to go through several repetitions before a satisfactory degree of consistency is reached, but the three-step nature of the project planning process is clear-cut. The first step, however, is logically prior to and independent from the recursive process which treats only of steps two and three.

1/ Almon, Clapper, "Consistent Forecasting in a Dynamic Multi-Sector Model," Review of Economics and Statistics, Vol. XLV, No. 2 (May, 1963), pp. 148-162.

The type of planning discussed here so far should be clearly understood as investment planning. Productive units in the economy are involved in two kinds of decisions; i.e., the pricing-output decision and the investment decision. That is, the firm must decide how much is to be produced and at what price it shall be sold. (In the long run these are, of course, not independent decisions since continued changes in inventory levels may signal a basic incompatability between price and production rate.) The firm also decides if and when it will change its productive structure by investment. This latter decision, the investment decision, is the planning problem that has been described here. However, planning has also been concerned with the output-pricing decisions. In particular, in the Soviet planning system the production operations of the firms are closely controlled from the center. The ideal planning process which has been of concern here has not included these quantity-price decisions. However, investment planning, as we have outlined it, is not incompatible with control over the output-price decision. The rule to be followed by the firm in reaching its pricing decisions will be important in establishing the desirability of carrying out the project. The questions of private versus public ownership or the autonomy of public enterprise managers do not concern us here. While they are at the heart of controversy over the extent to which output decisions are centrally planned, our interest is only in investment decisions.

B. THE EXISTING PLANNING SITUATION

This section notes briefly some of the differences which exist between the ideal sketched above and what seems to happen in actual planning.[1/] First, one can quickly dispose of the recursive nature of planning: this just does not exist in any operational planning organization. The internal ambience of planning organizations seems to fluctuate between a sense of boredom and neglect when the political authority chooses to ignore the efforts of the planning agency and a frantic scrambling to put together a plan or to study the wide range of economic policy questions which arise in the day-to-day activity of the government. Any recursive planning, adjusting various projects, projections, and policies towards an inner consistency, seems a dream of the future.

Instead, one finds a great shortage of projects about which anyone has even the most rudimentary information about benefits and costs. In fact, it is probably true that most countries have more resources available for investment than they have good projects upon which to spend. Emphasis has been put before on the importance of the empirical knowledge of the project universe, which is the only corrective for a shortage of good projects.

1/ Discussions of the reality of project planning which have been used here are: Hagen, E. E., (ed.), Planning Economic Development, M.I.T. Homewood, Ill.: Richard D. Irwin, 1963; Hirschman, A. O., Journeys Toward Progress: Studies of Economic Policy in Latin America, New York: 20th Century Fund, 1963; Waterston, Albert, Planning in Pakistan, Baltimore: Johns Hopkins University Press, 1963; Tinbergen, 1964.

Furthermore, the relation between projects and the foreign assistance providers is sharply different from that described in the ideal planning process. In many countries virtually all foreign aid flows are tied to specific projects which have been selected on the basis of a common interest between the assistance provider and the assistance receiver with virtually no analysis of alternative opportunities within the country. This tied aspect of development assistance seems inevitable due to the historical record of alleged or real irresponsible fiscal policies in less developed countries which has created a lack of confidence on the part of the assistance provider in the receiving country's capacity to put funds to good use without the discipline of a tied loan. The result is that projects are considered piecemeal, and little satisfactory effort is made to determine the best set of projects.

Both of these phenomena are associated with a more fundamental characteristic of the project planning process; i.e., the shortage of trained persons. There probably exists no greater need today in the less developed countries than training persons who can formulate and evaluate development projects. This difficulty results in a shortage of projects available for financing, and it shifts much of the burden of carrying out project studies onto the foreign assistance organization which, consequently, becomes involved in the project before there is a basis for adequate comparison between alternatives. However elegant the policy of valuation or the criteria for selection set up by the planning agency, in the absence of capable project planners in ministries and in public enterprises, adequate project planning will only take place for foreign aid projects.

In actual project planning there is usually insufficient coordination between the planning agency and the expenditure control organization. Hence, the important step of re-examining projects underway is largely neglected, so that the full range of alternatives is not available to the project planners. In addition, there may be many problems in relating project approval decisions to the budgetary process essential for thus insuring that resources are actually being allocated in the manner called for by the project selection process.[1/]

Most countries have great difficulty in shifting to the planning agency an important, much less key, role in project selection. Inevitably ministers and their aides resent intrusion in what they may feel is their domain. There is not very much useful to say about this. However, in project planning the planning agency may well be able to shift the decision burden to the ministries by providing an interest rate, the utilization of which would enable projects to be selected by ministries. The role of the planning agency would then consist of making aggregative projections, determining the proper interest rate for project selection, and training ministry officials in the correct techniques of project evaluation and selection.[2/]

It is difficult to make the project selection process comprehensive. Within the public sector, enterprises may carry out investment programs financed from earnings with little or no coordination with the planning agency.

1/ For example, see: Public Administration Service, Modernizing Government Budget Administration. Chicago: n.d.

2/ Hagen, 1963; Watson and Dirlan, 1965.

Outside the government there may be many private sector investments which lie beyond the control of the planning agency and, consequently, reduce the comprehensiveness of the project planning. The existence of a huge non-controlled private sector means the project planning will be only partial, and important interdependencies between investments may be neglected. Even when the control over the private sector is extensive, which is characteristic of less developed countries, this control is usually exercised by several different organizations, each of which may operate independently of the others. The range of possible controls over the private sector is sufficiently broad to lead to a proliferation of organizations to carry out control functions; e.g., offices for foreign exchange allocations, for industrial licenses, for import permits, for determination of tax exemptions and depreciation rules, and for lending to the private sector (development banks). Each such organization can have a substantial impact on the private sector, but each may operate independently (and one can find many examples of such independence). The lack of centralization and comprehensiveness of project planning is a pervading and permanent characteristic of the organization for economic development. What the project planning system must seek to achieve is a set of procedures which decentralize decision making by passing to the lower level decision maker information and criteria which will lead them to the same optimal selection that would have been reached under an ideal system.

In summary, then, project planning in practice is haphazard, with no real attempt at insuring consistency between the aggregative growth plan and the projects; it lacks both comprehensiveness and centralization. (To the extent centralization can be replaced by decentralized decisions this situation can be satisfactory so long as there is agreement between the planning agency and the ministries as to the criteria which ought to be used in decentralized investment decision making.) Further, foreign assistance is often tied to particular projects, and there is a tendency to consider a project which is under way as beyond reach of the planning process. Overriding all of these difficulties we have the shortage of adequate projects which tends to preclude any real process of selection. Until there is an adequate flow of projects, there can be no selection which truly reflects the economic situation of the country.

C. IMPROVING THE PROJECT SELECTION PROCESS

Since so many persons have attached such importance to the project selection problem as a key part of the development process, it is worth asking what can one do to make the situation better.[1/] It should be clear from the previous discussion that improving the number and quality of government officials concerned with project planning is the first step.[2/]

1/ Hagen, 1963; Waterston, A., "Administrative Obstacles to Planning," Inter-American Review of Economics, Vol. I, No. 3, (July, 1964), pp. 308-350; Waterston, A., "Planning for Planning," in Swerdlow, I., (editor) Development Administration Concepts and Problems, Syracuse: Syracuse University Press, 1963, pp. 141-162.

2/ Good text books which are relevant to the less developed countries and which do not require a high degree of economic sophistication are very rare. In fact, we do not know of any.

The competitive system suffers from an unrealistic requirement of the amount of information available to an individual decision maker, as well as market failures due to externalities. The totally planned economy also suffers from an enormous demand for information to be gathered at the center, so much that the allocation problem becomes unmanageable. Finally, in the corporate dominated type, perfect allocation is sought across a part of the capital market (that is, within the internal capital "market" of each corporation), thereby reducing the required flows of information or, alternatively, reducing the misallocation of resources arising from the failure of the requisite information to be generally available. The great importance of Step 1, stressed so much at various points in this paper, is, of course, an aspect of the need for information on potential investments to be available and known to the entrepreneurs. Once this is done, the critical question is to define the extent of centralization in project analysis and selection, thereby specifying the responsibilities of various parts of the government and translating the economists' prescriptions into specific administrative actions. In the development of orderly administrative procedures, it is vital that the project selection process be tied into the budget process. The two are natural complements of one another. The development of program budgeting is a step in this direction, but the project approach is more comprehensive and is aimed at analysis of the value of projects over longer periods of time.[1/]

1/ McKean, 1958; Mosher, Frederick C., Program Budgeting: Theory and Practice with Particular Reference to the United States Department of the Army, Chicago: Public Administration Survey, 1954.

The next significant step which needs to be taken is the careful integration of the various organizations and ministries which are concerned with encouraging and controlling investment in the private sector. On the one hand, there is great danger of drowning the initiative of the private sector by bureaucratic requirements and, on the other hand, too often each control organization has its own priorities for supporting projects. This issue raises complex problems of public administration, since the organizations involved may be in very different parts of the government. Once again, central to any forward progress is the need for a satisfactory supply of skilled people.[1/]

Finally, considerable thought must be given by the foreign assistance sources as how best to: (1) move further away from the too common present concept of selecting projects for loans independently of considerations of the desirability of the project within the framework set by the cost of capital within the country; and yet, (2) continue to finance skilled project planners to assist in the engineering and economic analysis that must be a part of project planning for all projects, both those financed with foreign assistance and those financed only from domestic resources.[2/]

1/ Brandenberg, Frank, The Development of Latin American Private Enterprise, Washington, D. C.: National Planning Association, 1964; Geiger, Theodore and Armstrong, Winifred, The Development of African Private Enterprise, Washington, D. C.: National Planning Association, 1964.

2/ The IBRD has started in the direction of providing project planning assistance without necessarily being interested in a loan. See also Transport Research Program, Brookings Institution, The Preparation and Evaluation of Transport Projects (unpublished).