PROJECT SELECTION WITH MULTIPLE MACROECONOMIC

OBJECTIVES: AN ECONOMIC EVALUATION MODEL

FOR THE DEVELOPING NATIONS

By

TESFAYE AKLILU
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Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1969

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1970

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of the Oklahoma State University
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Thesis Approved:

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Thesis Adviser

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Dean of the Graduate College

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CHAPTER I

INTRODUCTION

The major objective of this study is to extend the theory of
project selection in the public sector of a developing nation. It is
also intended for this research to indicate the inadequacy of a single
objective function (profitability) for the purpose of project selection.
Secondary to this, the research attempts (1) to outline the structural
requirements of the government organizations for an efficient capital
allocation program, (2) to outline the responsibilities of the dif-
ferent government agencies in the allocation of capital, and (3) to
present a rigorous formulation of the multiple objective model.

A survey of literature on public project evaluation quickly reveals
that most of the work is based on the concept of benefit-cost analysis.
In a majority of the cases, benefit-cost analysis was used as the sole
criteria for project selection. The literature also reveals that
recently an awareness of the existence of multiple objectives in
project selection have been shown through formulation of multiple
attribute models. Various modifications of benefit-cost analysis are
given by many authors to this end. The above statement is not intended
to mean that projects being considered by governments (specially in the
developing world) are at present evaluated by models which incorporate
the concept of multiple objectives. This is not so. It is going to
take some time for this to be the standard criteria. This is

essentially similar to the adoption of net present value in project

evaluation in the private sector. It took some time to convince

industries to change from the traditional pay-back period technique to

net present value (NPV). Even though NPV does give a better and more

consistent reflection of the economic environment, still at present

some industries use the traditional technique. In the public sector it

is even going to take more time and effort to make multiple attribute

models standard. Multiple attribute models as they exist today in the

literature or as it is formulated here are not designed to be 'the

answer' to project selection. All the effort is directed to improve

and build on the existing theory. It is meant to be a step in the right

direction and many more steps are needed before an adequate model is

developed.

The Problem

One element common to most public projects is the fact that they

are costly and require a large initial capital investment. A long

period of time is required before the impact of the projects is

noticed in the economy of the nation. It is unfortunate that sometimes

these projects are not fully studied in regard to their real economic

merits and impacts on the nation. But they are undertaken to impress

the outside world and to a certain degree the people of the nation.

To this end one could cite the uneconomic steel mills which have been

built as a symbol of national pride or the manufacturing plant whose

buildings are so elaborate that they cost three to four times as much

as the machines they housed. If a developing nation is picked at

random, and a calculation is made on the amount of capital invested on

public projects such as industry and agriculture for the last two decades, the amount will be very substantial. But the economic development which resulted from such massive investment is none or minimal at best. This contradicts the ill-conceived theory that more capital investment provides fast economic development. Unfortunately this was the belief of many government officials for it was sold to them by some experts in good faith without an examination of the host environment. These were experts who were so eager to contribute to the economic development of the developing nations that they attempted to duplicate the development strategy of the western world without the proper preparation. The problem now becomes one of finding an answer to the following questions:

1. Why was the millions of dollars invested in the developing nations unable to make a significant contribution to the country's development?

2. What are the prerequisites for an efficient capital allocation decision in the public sector?

3. What should be the criteria for such allocation problems?

The answer to (1) attempts to single out the errors committed and currently being committed. Knowing these errors, the answers to (2) and (3) will correct the errors and clear the path for a smooth economic development.

Objectives and Outline of the Study

In a situation where government activities are systematized and channeled into a logical work flow, public investment projects undergo various types of feasibility investigations. These might include

investigation of an engineering and technical nature to determine the

type of machinery, the size of machinery, and other structural or

physical aspect of the problem. Another investigation could be economic

feasibility studies to find out the desirability of the project from a

socio-economic point of view, the optimum scale of development and

ranking of the projects among available alternatives. It is with this

type of study that this research is concerned. A project evaluation

model which will measure the effectiveness of a project towards meeting

the goals of the government will be developed.

For some time now, the United Nations and other concerned inter-

national bodies such as the International Bank of Reconstruction and

Development, etc., have devoted a great deal of their energy and

resources to economic developments of the emerging nations. Some of

the studies show a large gap between the advanced and underdeveloped

nations. Moreover, these same studies reveal the unfortunate fact that

the gap is growing instead of decreasing. The governments of the

underdeveloped nations are becoming aware of the unbearable positions

of the people much more now than a decade ago. These same governments

are determined to take a major role in bringing about a steady growth

of economic development. In Chapter II the common economic character-

istics of developing nations are reviewed. The major social and

economic goals set by the governments are presented. The direct

relationship of public investment projects with the goals are outlined.

Certain elementary and intuitive characteristics which a 'good' public

investment project must possess are presented in Chapter II. It is

with these common economic characteristics and governmental objectives

as a base, that a method of analysis for economic evaluation of 'good'
public investments is to be synthesized.

In Chapter III the concept of public project evaluation is
reviewed. It presents a systems approach to the project evaluation
activity and outlines the functional responsibilities of different
government agencies vis a vis project evaluation. The need for
analytical criteria is then reviewed and a comprehensive survey of
literature is presented.

In Chapter IV a method of incorporating different and conflicting
government goals is presented. This method uses human judgement in
such a manner that a collection of consistent and appropriate economic
weights are achieved.

Chapter V discusses the major development objectives given in
Chapter II and formulates a measuring criteria for each objective.
These are integrated with the economic weights developed in Chapter IV
and a comprehensive project evaluation criteria is developed.

In Chapter VI an example problem is developed where the criterion
synthesized in Chapter V is used for economic evaluation of four
projects. To find the best project an integer programming (0-1) is
used. Sensitivity analysis is carried out to see how changes in
various economic parameters such as the economic weights affect the
choice of the projects. Conclusions and recommendations are presented
in Chapter VII.

CHAPTER II

THE PROCESS OF ECONOMIC DEVELOPMENT

The prevalent theories of economic development start off by identifying factors that affect the growth rate of the net domestic product, savings rates, investment rates, and trade levels. While useful in increasing an understanding of economic development, these theories and models do not provide a method for initiating developmental programs. They deal with the externals of the development process, its measurable symptoms and do not mention the organizational infrastructures which are necessary to implement the suggested theories and models. The trend towards increasing refinement, and theoretical elegance by theoreticians who also lack understanding of the basic nature of a particular developing nation, further add to the irrelevance of the models for those who, while deeply involved in the development process itself, are not economist. This is not meant to be a cynical remark about the contribution of economist but to indicate the importance of organizational structure and knowledge of the culture and value systems which will have a balance on the success of the models.

The majority of the developing nations do not know, exactly, how to initiate the developmental process, and at what point growth can become selfsustaining. While the understanding of the development process has been greatly increased as a result of the empirical and theoretical work already done, there is a lack of operational

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guidelines which would help in efforts to overcome the sluggishness or stagnation that seems to be inherent in most developing nations.

Reasons for the shortcomings of these theories may be, first that theoreticians do not consider the importance of the cognitive factors in development and growth. It is man's vision of the future, his hopes, fears, and expectations that determine his actions in the present; his awareness of the past influences him as well. It is impossible to understand the dynamics of a social system responding to new problems and challenges--and this is what development is all about--unless one also has an understanding of these hopes and aspirations as well as of the self image of the people within that system. And until one takes into account how man in a given society perceives his own problems, his interests and his goals, one really will have no clue as to how and why one will react in a particular way and not in another.

Secondly, economic development cannot be understood in isolation; it is part of a more general process of social transformation. Governments are not simply concerned with the attainment of economic goals; governments are dealing with major changes in a society, with the building of a new nation, with painful processes of disintegration and reintegration at various levels of society. Nation building has its own requirements: decolonization has left a number of African and Asian nations with a heritage of unsolved conflicts, resulting from or aggravated by the arbitrariness with which colonial boundaries had been drawn, the preferential treatment accorded certain ethnic or communal groups, and the existence of unintegrated minorities. National independence requires the welding of these, quite often disparate elements into a single polity capable of coping with the requirements

of present times. The goals and priorities, the phasing of economic development as well as the feasibility of specific economic policies inevitably are deeply affected by these overall nation building requirements.

Thirdly, a single criterion is characteristic of many proposed development models. For example, in the analysis of public investment, benefit-cost analysis is used primarily to measure profitability. It is important to realize that in national development, governments are not dealing with a single process of gradual and rational adjustment and redirection, but with discontinuities, with multiple and conflicting goals. Governments should be aware of the depth of human emotions, of the hope and fervor, the fear and despair which are involved, of the terrible violence and cruelity of which man is capable in extreme situations. At the same time governments cannot forget the immense magnitude and frightening urgency of the problems which threaten most developing nations. The growing unemployment problem, urbanization and increasingly inadequate educational systems--all of these problems make a rapid rate of development an essential pre-condition for the viability of many developing countries irrespective of their politico-economic systems.

The urgent question then becomes where and how should the study of economic development and the formulation of a framework for rapid and lasting progress begin. A major consideration of this research is to attempt to outline the major, common characteristics of such nations directed to answering these questions.

Major Characteristics of Developing Nations

Many terms are used by many people to identify nations which are
economically and technologically undeveloped. The terms underdeveloped,
developing, preindustrialized, backward, and emerging have been used
in the literature to mean the same thing and at times different things.
In this thesis the term developing is used to mean those nations which
are economically and technologically poor.

Governments of developing nations and international agencies such
as the United Nations (UN), International Bank for Reconstruction and
Development (IBRD) have collected data on the social and economic
conditions of such nations. It is possible to make use of this data in
finding some common characteristics of developing nations. An extensive
list describing these common characteristics has been provided by
Leibenstein (21). A partial list of major characteristics of developing
nations is presented here and mainly it is an outgrowth from
Leibenstein's work.

1. Most developing nations are burdened with factors which could
   hinder development. Multi-languages, different ethnic and
   tribal groups, religion and tradition are some of the
   forces one has to overcome. These cannot be taken lightly.

2. A large proportion of the population lives in rural areas.

3. There is low man-hour productivity in the rural areas. This
   is what some economists refer to underemployment or disguised
   employment. Total output will not be affected if the number
   of workers in the agriculture sector is reduced, provided
   adjustment is made in the technique employed.

4. The income distribution among regions and population is uneven. Consumption for the large mass of people is uneven.

5. The available invested capital is low. The economic surplus is controlled by a small percentage of the population, and their social values are not conducive to development programs for the large masses.

6. The land holding system is very feudalistic. The level of agricultural techniques and tools used are very primitive in nature. The yields per acre of land are low.

7. The only exportable items these nations have are raw materials and agricultural products which are returned back as finished goods. Such raw materials are so volatile on the international market that they create uncertainty as to the availability of cash. Most developing nations have balance of payments problems.

8. The private sector of the economy is undeveloped; hence, governments of developing nations must take the initiative in developing the economy. The result is a planned economy, not by choice but by circumstantial necessity.

The characteristics listed above are some of the major ones which are found in varying degrees in most developing nations. The listing of common characteristics is not designed to give the notion that developing nations are monolithic. Each developing nation must consider itself as a unique case when development strategy is being decided. The study of such characteristics should help in understanding the key problems that nations share in formulating some common objectives.

Overall Objectives

The foreward movement of a whole social system obviously depends on a broad consensus regarding goals (objectives) and means to obtain these goals; (that is, some shared vision of the future capable of arousing new hope). Unless realities can be seen with new eyes and hope translated into a sense of new profitable opportunities on the individual level, such vision of worthy goals will have little or no motivating value. At the same time the histories of new independent nations have made it clear that unless the new goals are related to prevailing notions, characteristics, attitudes and values, it is almost impossible to mobilize broad sectors of the transitional societies. Thus, it becomes imperative that one should commit himself to the study of the society; its characteristics and values before any attempt is made to prescribe a development strategy. A brief reflection of the type presented in the preceding section of this chapter gives a clear picture of existing conditions on which to base the formulation of overall objectives (in this research the terms objectives, goals and attributes are used synonmously).

It must be apparent by now that in order to carry on the development process a number of goals must be specified. These goals are decided by government policy makers. Bryce (3) has outlined some of the important objectives of industrialization, assumed by development economists. Tinbergen (33) has also investigated the planning process of various countries and the selection of economic goals. A summary of the main goals of economic policy in some selected group of nations is presented in Table I. It can be observed from the table that there exists a high degree of uniformity in the main goals nations have.

TABLE I

MAIN AIMS OF ECONOMIC POLICY OF THE GOVERNMENT

Country	Aims						Other
	To increase national income	To improve employment situation	To achieve and maintain balance of payments equilibrium	To achieve and maintain price stability	To obtain a more equal distribution of income between individuals	To obtain a balanced regional economic development	
Burma	x	x	x	x	x	x	To achieve an increased rate of growth of population.
Ceylon	x	x	x	x	x		To diversify the economy so as to make it less vulnerable to external changes
Chile	x		x	x	x		
Czechoslovakia	x	x	x	x	x	x	Fundamental aim: To ensure material and cultural conditions for the development of the society and of every individual.
Ecuador	x	x	x	x	x	x	To improve education and a achieve system to technical education. To eliminate feudal relations that permit exploitation of working people.
France	x	x	x	x	x	x	To produce resources for aid to underdeveloped countries.
Greece	x	x		x	x	x	Progressive diminution of the dependence of the Greek economy on foreign economic aid.
Hungary	x	x	x	x	x	x	
Iran	x	x	x	x	x	x	
Japan	x	x	x	x	x	x	To achieve economic self-support.
Federation of Malaya	x	x	x		x	x	To widen variety of Malayan production.
Morocco	x	x				x	To establish economic independence of Morocco.
Netherlands	x	x	x	x	x	x	
Norway	x	x			x	x	Prevention of inflation: long-term external balance of the economy.
Poland	x	x	x	x		x	
Puerto Rico	x	x		x	x	x	
Turkey	x	x		x	x	x	
						x	
Yugoslavia	x	x	x	x	x	x	

Source: Tinbergen, Jan., Central Planning, Yale University Press, 1964, pp. 104-142.

As Bryce (3) points out one of the soundest motives of economic policy is to increase the national income of the country. Any investment project can result in any one of three possibilities. It can add to the national income, it can reduce the national income, or it will have no effect, either positive or negative. If a project makes a positive contribution to the national income, it meets one of the basic objectives of economic policy. Such positive contributions will overcome one of the major characteristics of a developing nation--the scarcity of capital. In a situation where capital is scarce, it is illogical to consider a project which will harm the economy due to negative contribution to the national income. A project which is not capable of supporting itself financially is bound to require the rest of the economy to subsidize it. This is an unnecessary strain on the economy that cannot be easily resolved. Investment projects which are analyzed and studied correctly and well run when they are built can make an immense contribution to the economy of the nation. Such potential projects are plentiful in most developing nations. However, they do require a lot of soul-searching and committment to get them started.

Another main goal which is listed in Table I and frequented by most nations is the goal of employment creation. The merits of this objective are based on the economic, social and political scales. Economically more employment means more people have the capacity to consume the services and goods the nations' economy supply. Increased demand for such goods and services means more economic activities. The standard of living, the per-capita income, the welfare of the people and other economic indicators will improve. There must, however, be a

clear distinction between productive employment and disguised employment. This thesis refers to productive employment where man-hour productivity is related to the general economic level of the nation. Disguised employment is a regular feature of developing nations. Project selection in the sense of this thesis does not accept such a notion. Socially, employment can keep the basic social fiber intact. Crime, theft and other social ills are related to massive unemployment. Politically, the unrest and upheaval of most African, Asian and Latin American nations can be attributed to economic malaise and unemployment. Hence, there is a good and sound motive to make employment one of the objectives.

A major and basic objective of many developing nations is one of maintaining a balance of payment equilibrium. Investment projects are a means to improve the stability of foreign exchange earnings. A proper choice of investment projects can release badly needed foreign exchange so that it can be used to purchase the heavy machinery and technology needed for development. There is no justification for a nation to import items which it can competitively produce at home.

The distribution of income among regions is another major objective of a developing nation. Observations of African, Asian and Latin American countries reveal that nearly all of the economic activity is centered around one city. In a great many countries the contrast between the economically active city and the rest of the country is very apparent. People from rural areas flock to the city with the hope that their problems are better solved here. But to most, these expectations are never realized. Too much centralization of economic activity in one city does more harm than good. A major effort must be

made to distribute economic activities into the appropriate regions

for a more balanced and self sustaining growth.

Tinbergen's study indicates that most nations are using direct

public investment as the means of achieving the overall objectives dis-

cussed above. This is the central theme of this research--that public

investment is the most appropriate tool for rapid and lasting economic

growth. Based on this premise, this thesis attempts to investigate the

proper methods of selecting such projects. However, before the develop-

ment of such criteria, it is helpful to study the characteristics of

sound projects.

Characteristics of Sound Projects

Bryce (3) starts out by saying that investment projects, aside

from being technically and economically sound, should fit in with the

long-term economic trends and needs of the growing economy. Investment

projects can not be taken haphazardly, they have to mesh into some sort

of a logical, sequential system where the timing and scale are given

the top most consideration. (An input-output matrix can help in laying

down the logical flow of investment projects.) The following are

general characteristics which good, sound projects should have.

1. In the developing nations, investment projects should have

    a ready established market for their products, either at

    home or abroad provided it meets some standards of quality

    and competitive price.

2. A good investment project should have some production

    advantage over others. Bryce puts it convincingly when he

    wrote,

> An underdeveloped country, lacking the legacy
> which an unusual resource represents, is more
> likely to be in a position where it must build
> what it wants—industry—largely on the strength
> of what it already has—agriculture (p. 5).

This gives the advantage of having the raw materials at hand.

It also fits the economy in the sense that one sector's

output can be used as an input in another sector. Such a

linkage is an essential feature of good planning. Besides

functioning as a part of the present structure of the

economy, it must fit into the next phase of economic develop-

ment, either supplying consumers with goods they need in that

phase, supplying investment goods for the investment activity

in that phase, or supplying an input into another productive

activities in that phase. This linkage of the project with

both the present and the future, looking back to its inputs

and forward to expanded future markets, is a feature

possessed only by truly dynamic and profitable projects.

Summary

This chapter touched upon some of the prevalent economic theories,

their contributions and drawbacks. It gave an account of the major

characteristics of developing nations and from this developed a set of

overall economic development objectives. These are listed here for

reference:

1. Maximize national income.

2. Maximize productive employment.

3. Maximize the earnings of foreign exchange.

4. An equitable distribution of income among all regions.

As a means of attaining these objectives rapidly and in a lasting manner, the strategy of public investment is preferred. The next chapter deals with a systems approach to project analysis and with some of the analytical criteria developed up to this time.

CHAPTER III

THE ANALYSIS OF PUBLIC PROJECTS

A Systems Approach

The process of project analysis to be presented in this chapter is based on the concept of systems analysis. In general, systems analysis can be viewed as any orderly analytic study designed to help a decision maker identify a preferred course of action from among possible alternatives. It provides a basis for an intensive study of complex phenomena that are in some way related within the defined boundries of a unified system. Systems analysis is employed here as a conceptual and analytical tool to facilitate an understanding of the essential structure of the complex system of public project analysis.

Systems analysis is a prerequisite to the successful development, evaluation and selection of public projects. In order to assign a meaningful capital allocation to public projects, it is imperative to study and analyze the entire system. Beginning with a lucid economic philosophy and explicit operational objectives, the project analyst should emphasize the analysis of the alternatives which are believed to achieve the objectives. In many cases, the systems analysis approach results in a schematic representation of the different activities and their interrelationships. As can be observed from the flow chart shown in Figure 1, a schematic representation

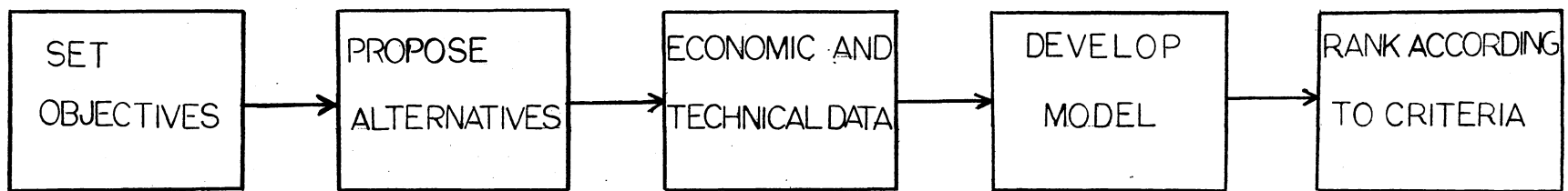| SET OBJECTIVES | → | PROPOSE ALTERNATIVES | → | ECONOMIC AND TECHNICAL DATA | → | DEVELOP MODEL | → | RANK ACCORDING TO CRITERIA |

Figure 1. Systems Approach of a Problem

provides a general understanding of the activities involved. Figure 1
depicts the five ingredients of a systems analysis approach. Quade (31)
writes that these five activities are always present in every analysis
of choice and should always be explicitly identified.

1) <u>The Objectives</u>. The complex process of planning always
   starts with the setting of objective(s). This is the first
   and most important task of the analysis. The objectives have
   to be clearly defined and understood. The entire activity
   which follows pertains to the objectives and unless the
   objectives are set and agreed upon the whole process will fail
   to accomplish anything of value.

2) <u>The Alternatives</u>. Once the objectives are agreed upon, the
   analyst starts exploring ways and means of achieving the
   objectives. These are referred to as the 'alternatives'.
   These may be policies, strategies, or specific actions. Thus
   a fertilizer industry, a textile mill, or a meat processing
   industry might be considered as alternative means in combating
   unemployment and increasing national income at the same time.

3) <u>Technical and Economic Information</u>. If these alternatives are
   assumed to have the potential of achieving the objectives,
   their implementation implies an expenditure of funds which
   could have otherwise been spent for other purposes. These
   costs and the future benefits should be recorded for the
   purpose of evaluation. The evaluation determines how
   efficiently and economically each alternative accomplishes
   the objectives. These economic and technical informations

comprise the third activity of the systems analysis approach

shown in Figure 1.

4)   The Model.   The recording of the economic and technical

information leads to the development of the model by which

each alternative is evaluated.   A model is a simplified,

stylized representation of the real world.   Johnson, Kast,

and Rozenzweig (17) described a model as a common technique

of abstraction and simplification for studying the character-

istics or behavioral aspects of objects or systems under

varying conditions.   In systems analysis, as applied to

public project selection, the role of the model is to

evaluate the projects (alternatives) on the basis of the

extent to which the objective(s) would be attained and how

economical the alternatives are.

5)   The Criteria.   The fifth and last activity indicated in the

flow chart is the establishment of a criteria by which the

best alternative(s) can be selected.   The criteria is a rule

or standard which will enable the analyst to rank the alter-

natives in order of desirability.   This completes the systems

analysis cycle.   As can be observed, the systems analysis

approach is not a complicated process, rather it is a logical

work flow that tries to accomplish a given task by dividing

it into its simplest elements and proceed step by step

following the logical precedence of the simplest elements.

It simplifies the understanding of the problem, which enhances

the possibility of a successful completion of the task.

The Process of Project Analysis

In general, the process of project analysis, frequently studied in capital budgeting problems, has three distinct activities. In the capital budgeting problem, the objective is to maximize the wealth of the shareholders. To achieve this objective, projects are initiated by the operating staff of a corporation. This is the first activity shown in Figure 2. Project initiation is the first step of project analysis. Once the projects are initiated, they are evaluated for their economic desirability. The second activity, project evaluation, inputs the costs and benefits of the projects with its appropriate discount rate into the model (net present value model), and evaluates the net present value of each project. The third and last step is the project selection process. This activity ranks the projects in order of their net present value. The project with the highest net present value is ranked 1, and the second highest 2, etc. The criteria then is to select the project(s) with the highest net present value. This, of course, is not a complete description of the capital budgeting problem. Rather, it is a simple version for the purpose of introducing the three major activities involved in the analysis process. With this introduction, the public project analysis is discussed in the following section.

Analysis of Public Projects

Figure 3 shows schematically the logical flow of the process of public project analysis. The boundries drawn in the flow chart separate the tasks by functional responsibilities of the various bodies concerned

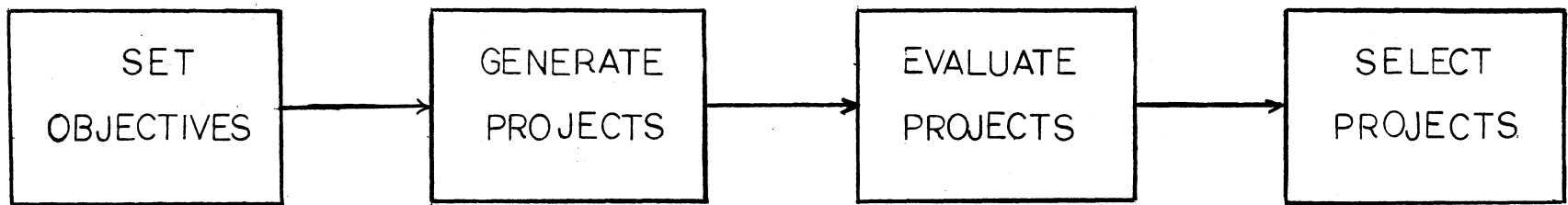| SET OBJECTIVES	→	GENERATE PROJECTS	→	EVALUATE PROJECTS	→	SELECT PROJECTS

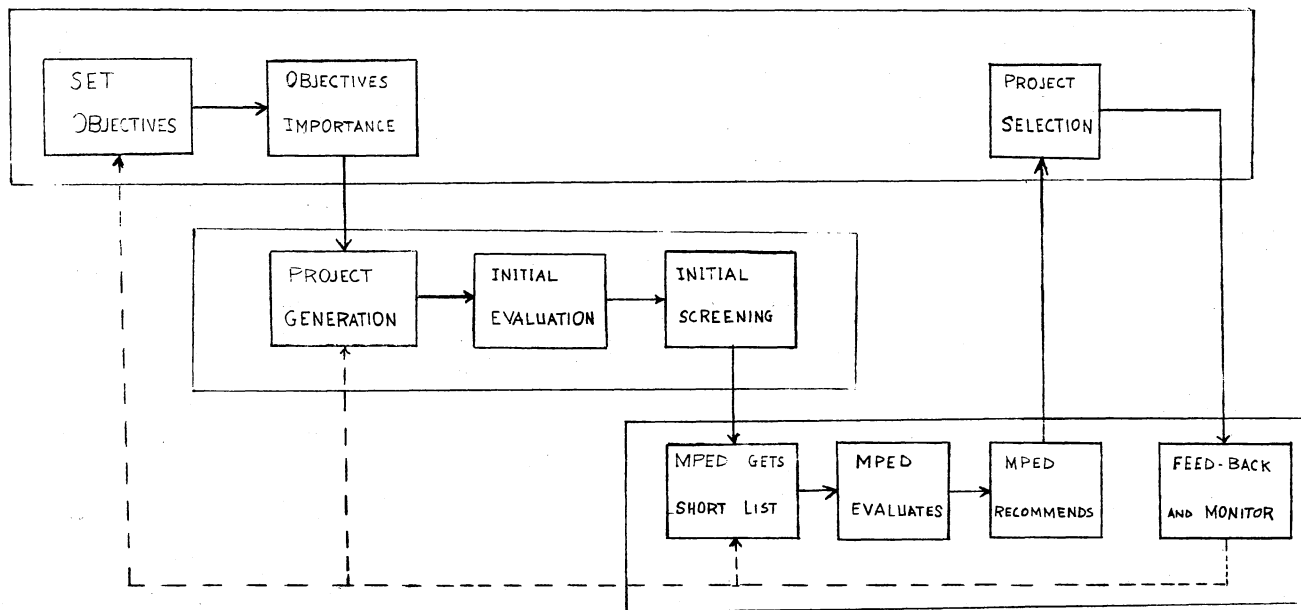Figure 2. Process of Project Analysis

Figure 3. Public Project Analysis

with project analysis. It is suggested here that projects be subjected

to the scrutiny of three distinct government bodies; namely, the

Central Economic and Planning Board, operational government agencies,

and the Ministry of Planning and Economic Development.

Central Economic and Planning Board (CEPB)

The board members of the CEPB are selected from among the council

of ministries and other agencies based on their functional responsi-

bilities. The following membership suggestions cover all the

pertinent agencies which will have substantial input into the project

analysis. The list includes:

    Head of Ministry of Planning and Economic Development (Chairman)
    Head of Ministry of Finance (Vice-Chairman)
    Head of Ministry of Agriculture
    Head of Ministry of Education
    Head of Ministry of Labor
    Head of Ministry of Commerce and Industry
    Head of the National Bank
    Head of the National Chamber of Commerce

The CEPB is a policy setting body in the area of economic develop-

ment. The Board overlooks the overall economic activity of the nation.

The Ministry of Planning and Economic Development (discussed subse-

quently) provides the secreatariate of this Board.

Various Operational Government Agencies

The second government body which concerns itself about project

analysis are the various agencies of the government. Projects have to

be initiated by concerned agencies. There can not be a central body

which initiates projects. The agricultural department is concerned

with agricultural projects, the department of commerce and industry

with manufacturing projects and so on. Independently these operational

agencies must provide potential projects. Each government agency must

organize itself such that project development and planning is

encouraged. Accordingly, it is imperative that each concerned agency

must establish a Planning and Programming Unit (PPU) within its organ-

ization. This unit will be responsible for project analysis for its

respective department.

Ministry of Planning and Economic Development

This ministry is the national coordinator of all public project

investments and other related economic activities. All public projects

are evaluated and final recommendation prepared by this ministry before

they are routed to the CEPB for final selection. These are the three

bodies which are concerned with project analysis. The activity chart

represented in Figure 3 are performed by these three agencies. The

following is a discussion of the flow chart.

Step 1. Set Objective(s). The first task in an environment,

if it is to be done systematically, is the setting of objectives. This

might be stating the obvious, but many plans and activities are under-

taken in the developing nations without taking the time to outline the

objectives. Many government investments are chosen haphazardly and

without any specific goals related to a development plan.

The economic development objectives must be studied by the experts

of the Ministry of Planning and Economic Development and presented to

the Central Economic and Planning Board for approval. Generally the

overall objective of the developing nations is to improve the general

welfare of the populace. In Chapter II, the most often used objectives

were listed and it is assumed that this set of objectives will best

achieve the desired improvement of the welfare of the populace.

Step 2. Determine Relative Importance of Objectives. The

different objectives listed in Chapter II may or may not have equal

impact on the welfare of the people. National income might be more

important than balance of payment, if so, the question of degree of

importance must be determined. Similar to the setting of objectives,

the determination of relative importance of objectives is a policy

matter and is set by the CEPB. Chapter IV deals with a specific

approach of assigning weights to such objectives.

These objectives and their relative weights serve as a guideline

by which the operation of project analysis should be conducted. These

are documented with other informations and regulations and distributed

to all concerned agencies.

Step 3. Project Generation. Prospective projects are initiated

and formulated by the Planning and Programming Unit of each concerned

agency. For example, the PPU of the Agriculture Department might be

considering a fertilizer industry, an irrigation project, a big

mechanized agricultural project, or a dairy industry. These might be

the result of the research conducted by the unit. The PPU of Commerce

and Industry Department might be considering a textile industry or a

tire plant. The import data on these items might have convinced the

PPU that such projects might have a big potential. Whatever the cause,

the PPU of all departments are highly encouraged to generate potential

projects. This sets in motion the project analysis procedure.

Step 4. Preliminary Evaluation. A preliminary evaluation as to

the economic and technical feasibility of the projects is carried out

by the Planning and Programming Unit sponsoring the projects. The actual work might be done by an outside staff or by the PPU staff itself. The economic evaluation is done so as to indicate the profitability of the project. At this stage of the evaluation only the profitability objective is considered. Net present social value is used to determine the profitability of the projects. A description of this and other analytical models will be presented later in this chapter.

Step 5. Narrow List of Potential Projects. An initial screening of the first set of potential projects is conducted by the respective PPU's. This screening is done on the basis of the preliminary evaluation (net present social value). All projects which are found not to be self supporting are removed from the list. This is a departmental evaluation and final approval is given by the particular department head.

Step 6. Narrow List Presented to MPED. The Ministry of Planning and Economic Development receives the final list of prospective projects from all agencies. The PPU of each agency is responsible for formulating and documenting all information on its respective set of potential projects. All required economic and technical data must be presented to the MPED. Once projects are presented, a Project Development Committee is to be formed to steer the projects through the various stages of development. This committee consists of representatives of the PPU of the relevant ministry/agency and the MPED. The MPED may request further details and may request that further work be done by the sponsoring or executing ministry or agency.

Step 7. MPED Appraises Short List. Within the MPED, the sub-

stantive technical and economic appraisal is made in the first instance

by the relative sector departments. Agricultural projects are

appraised by the Agricultural section of the MPED. This sector

evaluation emphasizes on the fitness of the project to the overall

development activity within its own sector. The Project Coordination

Division of the MPED reviews each project from the point of view of

inter-sectoral planning and coordination and to ensure minimum

standards of project evaluation. The Project Coordination Division

employs the multiple attribute, intersectoral model which is developed

in Chapter V of this thesis. The Project Development Committee over-

sees the work of the experts of the sector departments and the Project

Coordination Division. Each step of the evaluation done by the MPED

is given to the Project Development Committee and the committee's

opinion is related back to the experts through the representative of

the MPED. At any time, if the committee feels it is important, they

can summon the appropriate experts for explanation of any aspect of the

analysis. The task of the Project Coordination Division is probably

the most important one in the process of project analysis. The model

used should reflect the actual environment and the result of the model

must be in such a form as to guide the decision maker in arriving at

the best possible decision. A complete study of the model is given in

Chapters IV and V and an example is worked in Chapter VI.

Step 8. Project Recommendation. The projects, as submitted by the

Minister or Head of the sponsoring agency, together with any proposed

amendments and the appraisal of the sector department and the Project

Coordination Division of the MPED is examined by the Project Development

Committee. This Committee may recommend acceptance, rejection, or modification and reappraisal of projects. The recommendation of this committee is then sent in writing to the members of the Central Economic and Planning Board for final approval. Each member of the CEPB is kept informed about the project, from the very beginning until the final recommendation of the Project Development Committee by their respective representative on the Committee. Throughout the process, the members of the Committee are in touch with their superiors for consultation and for regular briefing of the development.

Step 9. Project Selection. The final approval is made by the Central Economic and Planning Board. The approved projects are then routed to the sponsoring agency for implementation. In many instances because of development budget constraints some acceptable projects will not be approved. Such projects are not completely eliminated. The CEPB will normally recommend such projects be included in the next development budget and evaluated with the next set of potential invest- ment proposals. This type of phasing of projects must be given considerable attention in order that potential investment plans are not lost.

Step 10. MPED Monitors Implementation. The implementation of projects does not end the process of project analysis. The MPED must monitor the implementation phase. Information and statistical data gathered from projects will be documented and analyzed for future reference. This is one source of improvement which can aid the process of project analysis in the future. All projects selected and imple- mented are not guaranteed to contribute according to the forecast. Some projects will overachieve while others will underachieve. Such

followup will enable the experts to gain greater insight and experience and, consequently, will increase their judgement and knowledge in regard to future decisions. New information obtained should be relayed to all concerned so as to build a current file of information within the different agencies and MPED.

The outline, thus far, has discussed the flow chart shown in Figure 3. As is mentioned earlier, the selection of projects is only as good as the data input and the model used. This thesis deals with the model building part of the project analysis. For the type of public investment being studied, the need for a sound analytical model cannot be overemphasized. It should be noted that such a detailed procedural outline can indicate the importance of the investments and their general impact on the economy. It cannot, however, offer criteria through which prospective projects can be evaluated and the optimum set selected.

<div align="center">Need for Analytical Model</div>

It was stated in the last section that an analytical model is required in order to evaluate and select the optimum set of projects from among projects in the different sectors of the economy. The analytical model will require certain simplifying assumptions so that it can be manageable. However, simplification does not mean that the model becomes an unacceptable representation of the real world. Whatever representation is lost through assumptions and simplification, is compensated through deliberate and conscientious human judgement. The model is an aid to decision making and, as such, should have built within it the dynamic interrelations among the different variables present.

In the developing nations a lack of enthusiasm and interest with regard to the use of analytical models for decision making is wide-spread. There are several reasons for this and some of the important ones are mentioned below:

1. Some evaluation models are simplified for certain reasons to the extent that the models do not reflect the real economic situation of the country. These models, when used as decision making tools, result in decisions which are wrong and costly to the nation. This fact has disillusioned some people and their faith in such models has eroded due to high expectations.

2. Statistical data on which the models are to operate are not available. The sophistication of the model loses its weight due to the lack of reliable data input.

3. The third reason is more common and widespread among developing nations. Well trained and experienced personnel are not available (and will not be for some time) to analyze and interpret the complexities of such models. The importance of such personnel cannot be overemphasized.

In general, the scientific methods used in the developed world cannot be implemented in most developing nations as they are. Statistical data is lacking and the available engineers are not yet familiar with the complicated calculations of operations research and the like. Such services are indeed available at the many United Nations agencies. Hence, the lack of experienced personnel should not prevent the use of sound economic evaluation models in developing nations. However, care must be taken on how the United Nations experts

are utilized. It must be planned in such a way that local personnel

are assigned to these experts as counterparts with equal authority.

Such involvement from the very beginning of the process will create a

sense of belonging and commitment that will help the projects' chance

of success. It also serves as a training ground for local personnel.

As stated before, there is a necessity to find and formulate an

economic model that is not oversimplified so as to lose its value and

a model not so complicated as to lose the people it is to serve. Such

a model will aid in evaluating the real economic merit of a project

and to base decisions on an objective evaluation. Before such a model

is developed in the succeeding chapters a survey of the available

analytical models is presented here.

<center>Survey of Analytical Evaluation Models</center>

Single Objective Models

Benefit-Cost Analysis. The concept of benefit-cost analysis has

been used widely in the economic evaluation of public projects here in

the United States and in other developed nations. In this country the

concept has been extensively applied to evaluate the desirability of

water resource projects. Benefit-cost analysis has been used as a

device to establish the economic feasibility of a project and to rank

projects in order of desirability.

The benefits and costs of a project are estimated for the entire

life of the project. The methodology employed to calculate the

benefits and costs associated with a project differ from project to

project. The study of these techniques is outside the scope of this

thesis but appropriate references are given in the bibliography. The benefits and costs of each year are then discounted back to the present. The ratio of the discounted benefit and cost is the criteria used to evaluate projects. Mathematically the BCR of project j is given by

$$(BCR)_j = \sum_{t=1}^{n} B_{t_j} (1+i)^{-t} \bigg/ \sum_{t=1}^{n} C_{t_j} (1+i)^{-t} \qquad (3-1)$$

where

B_{t_j} = benefit of project j for year t,

C_{t_j} = cost of project j for year t,

n = life of project j, and

i = appropriate social rate of discount.

If BCR is used as an indicator of economic feasibility the criteria used is that all projects with a BCR greater or equal to unity are feasible.

$$BCR \geq 1 \text{ (indicates feasibility)}$$

If the BCR is used to rank projects, then the project with the highest ratio is ranked first while the project with the lowest feasible ratio is ranked last.

The benefit-cost analysis is concerned mainly with the profitability of the project. In the analysis of public projects there are other equally important and, at times, more important objectives that the BCR does not cover.

Social Marginal Productivity. The social marginal productivity (SMP) was first introduced by A. E. Kahn (18). Kahn suggested that efficient allocation of public funds is achieved when the value of

national product is maximized and the rule for such optimum allocation of resources is for the social marginal productivity of capital to be approximately equal in different uses. H. B. Chenery (8) attempted to quantify Kahn's suggestion by applying it to a number of empirical situations in several countries. Chenery has also added, in his formulation of the SMP, the effect a project has on the balance of payments. The equation of Chenery has the form

$$\text{SMP}_j = \frac{V_j}{K_j} - \frac{C_j}{K_j} + r \frac{B_j}{K_j} \qquad (3\text{-}2)$$

where

V_j = social value of products of project j sold domestically,

C_j = total cost of domestic factors, labor, material, etc., during the operation of project j,

B_j = total balance of payments effect of project j,

K_j = capital investment in project j, and

r = ratio of social value of foreign exchange to its market or its regulated price.

The SMP criterion is a static model. It does not include the effect of present investment upon the amount available for future investments. In other words, the SMP criterion does not identify the amount of products from present projects going to reinvestment and consumption. Eckstein (13) has stated that the SMP criterion is not proper for finding the scale of a project. Eckstein argues that Chenery's formula

> ... is a marginal concept insofar as it reveals the contribution of any one project to the program, assuming that the choices are defined in terms of adding or subtracting projects (13, p. 59).

Maximum Employment Absorption. Earlier in Chapter II, the economic characteristics of developing nations were outlined. One of the common characteristics mentioned was the existence of massive surplus labor. A high degree of unemployment in the urban centers and underemployment in the rural areas is a common feature of developing nations. To combat this economic waste of a valuable resource, many economists advocate the use of projects that mobilize the largest labor force. That is, projects which use the maximum about of labor per unit of investment are preferred. Mathematically, this approach is based on the ratio

$$\frac{L_j}{K_j}$$

where

L_j = total labor force employed in project j, and

K_j = capital investment in project j.

This criteria of maximum labor absorption would eventually lead to low labor productivity. Unless proper precaution is taken, it might result in disguised employment which is chronic to economic development. The opposite of this criterion is the capital-intensive model. In this approach, a high degree of labor productivity can result and overall project efficiency and productivity can increase. Even though the immediate employment situation is not improved through the use of capital intensive techniques, in the long run, due to increases in productivity and rate of capital accumulation, it can provide greater employment opportunity. In some developing nations, both labor-intensive and capital-intensive techniques are used. This might sound contradictory but production techniques using a small capital/labor

ratio (labor-intensive) are being recommended in the agriculture
sector while modern capital-intensive techniques are encouraged in
industry. A good balance of the two methods is desirable.

Multiple Objectives Models

The most basic proposition in public expenditure economics is that
society should undertake all projects, within the development budget,
whose implementation adds more to the welfare of society than it
subtracts. The use of profitability or efficiency criteria alone to
evaluate public projects is a very limited and narrow interpretation of
this basic proposition. The application of single objective criteria
implicitely assumes the following functional relationship:

$$\text{Social Welfare} = f \text{ (profitability)} \qquad (3\text{-}3a)$$

This is an oversimplification of the problem. In effect, society
is concerned with other social objectives which are as important as
the profitability objective. Such social objectives as employment,
balance of payment and income distribution are the ones considered in
this thesis as having a considerable impact on social welfare. In
other words, for this research, it can be explicitly stated that:

$$\text{Social Welfare} = f \text{ (national income, employment, balance of payment, income distribution)} \qquad (3\text{-}3b)$$

The conventional efficiency criteria, in which the difference
between money valued benefits and costs is maximized, is not accepted
in this thesis on the basis of the argument presented above. The
implicit assignment of zero values to all other objectives is contra-
dictory to the principle of optimum allocation of public funds. Some

of the prominent literature on multiple objectives are discussed in the

next section.

McKean's Approach. Roland N. McKean (15) suggests that the

decision maker be provided with the profitability evaluation measured

in monetary units. This calculation measures in effect the difference

between the benefits and costs of the projects. Along with this net

money valued benefits, McKean suggests that the decision maker be also

provided with a measure of other non-money valued benefits and their

description. The decision maker then selects the project which conform

best to his subjective evaluation and interpretation of society's

preferences of money valued benefits vs. other benefits. A hypothetical

problem is presented in Table II using the format suggested by McKean.

TABLE II

MONEY VALUED AND UNVALUED BENEFITS

Projects	Net Money Valued Benefits	Measurable Unvalued Benefits
A	$10,000	9 units
B	$13,000	8 units
C	$17,000	5 units
D	$20,000	2 units

Project A gives a net benefit of $10,000 and nine units of other benefits, while project C has $17,000 and five units, respectively. The question is to find the tradeoff between A $1 dollar benefit and a unit of the other benefit. According to McKean, society has to rely on the wisdom and judgement of the decision maker. If the decision maker's choice is project C, he foregoes a benefit of an additional $3,000 for an increase of three units of the unvalued benefits. This determines the exchange rate. A unit of the unvalued benefit has equal value as a thousand dollars.

The basic question in McKean's approach is in the ability of the decision maker to reflect society's preference in his judgement. This is highly questionable and for this reason cannot be supported unless some control and check system is utilized. Such complete reliance on one man's judgement without an explicitly and objectively stated relative value can lead to suboptimum results.

Marglin's Approach. Stephen Marglin (15) has suggested a bounding technique to handle multiple objectives. Marglin proposes that a minimum value be established on the n-1 objectives and that maximization of the last objective be carried subject to the established minimum values. In this bounding problem Marglin writes that the n-1 objectives can be selected on the basis of analytical convenience or if one of the objectives can be identified as the most important then this determines the n-1 objectives that need to be constrained. In the example problem tabulated in Table II, if the minimum acceptable measurable unvalued benefit is six units, then project B has to be selected since it maximizes the net money valued benefits. Mathematically Marglin's suggestion can be formulated as

$$\text{Maximize} \quad \sum_{j=1}^{m} B_j X_j \qquad\qquad (3\text{-}4)$$

$$\text{Subject to} \quad \sum_{j=1}^{m} MB_1 X_j \geq \text{Lower Limit}$$

$$\sum_{j=1}^{m} MB_2 X_j \geq \text{Lower Limit}$$

$$\sum_{j=1}^{m} MB_{n-1} X_j \geq \text{Lower Limit}$$

$$X_j = 1,0$$

where

B_j = measure of the objective to be maximized associated with project j,

X_j = project j,

MB = measure of the objectives that are constrained (there are n-1 of these),

n = total number of objectives, and

m = total number of projects being considered.

Marglin's method offers a considerable improvement over McKean's approach. The limitation in Marglin's case is establishing objectively and realistically the lower bounding limits for the n-1 objectives. Such limits might exert unjustifiable restrictions which might underrate prospective projects. It might also overrate some if the limit is relaxed.

Benefit-Cost Ratio for Multiple Objectives. The traditional
benefit-cost ratio is modified by David C. Majors (25) to incorporate
multiple objectives. Major developed the model for two objectives. It
was assumed that the objectives of investment in water resources are to
increase the national income and to increase the income of a single
specified region. An example of national income according to Major is
the willingness of users to pay for the outputs of the project, while
regional income benefits are equal to the willingness of users to pay
in the specified region minus any charges for output imposed on the
users. The analysis here is to generate relative weights for the two
objectives. Figure 4 depicts the approach taken by Major to derive the
relative weights.

The set of feasible set of combinations of national income and
regional income is given by line T in Figure 4. The line T which Major
calls 'Net Benefit Transformation Curve' is obtained from an input-
output matrix or other economic analysis. The two curves W_1 and W_2
are two of a family of indifference curves representing society's
ordering of combinations of the two objectives. These indifference
curves, according to Major, can be obtained from decisions made by an
informed legislative process. Based on an empirical analysis conducted
by Maass (22), direct interpersonal utility comparisons are not
necessary. Legislative process as the one in this country can achieve
the same result.

The best attainable combination of national income and regional
income is at the point where the transformation curve T is tangent to
the highest attainable social indifference curve. In Figure 4, this
point is labeled A. The slope of the tangent line gives the relative

NET NATIONAL
INCOME BENEFITS

SLOPE
= -.4
SLOPE
= 0

A
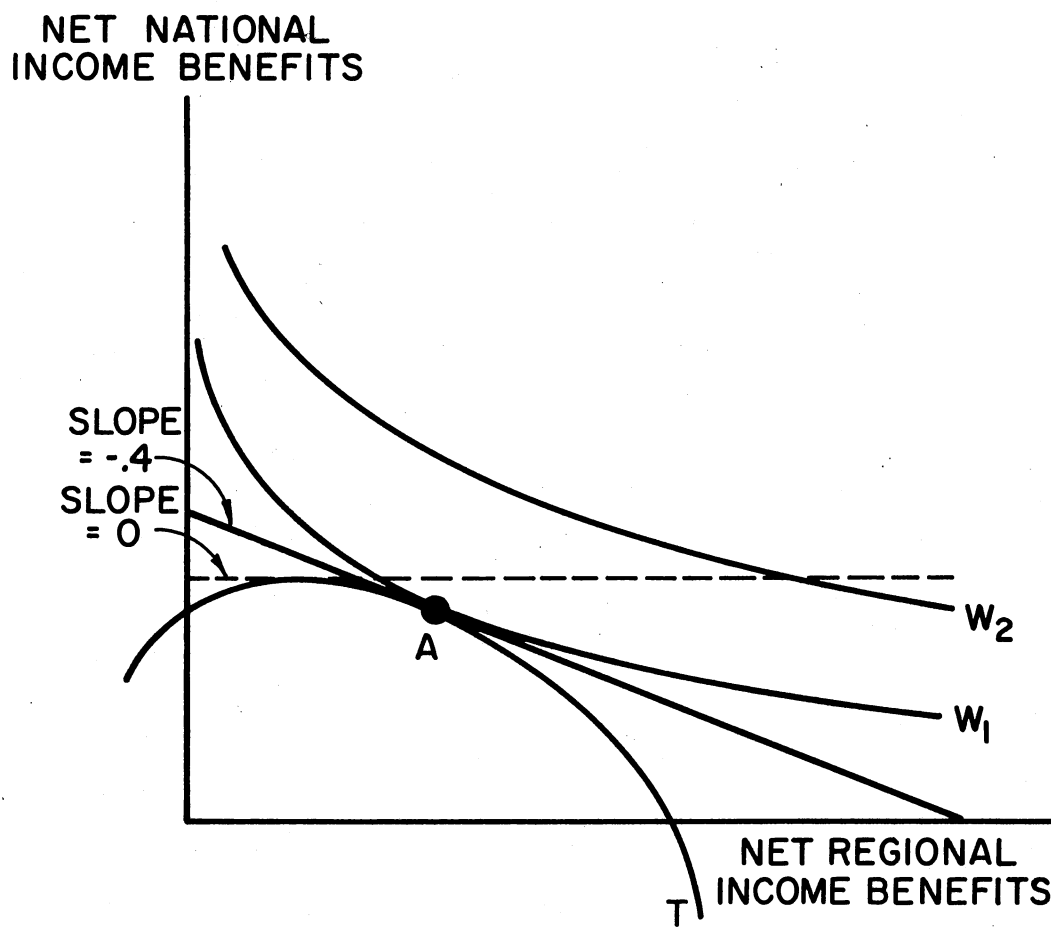
W₂

W₁

NET REGIONAL
INCOME BENEFITS

T

Figure 4. Graphical Representation of Economic Weights

marginal social values placed on net national income and net regional income. If the price of 1 is assigned to one dollar of net national income, the price of one dollar of regional income is given by the negative of the slope of the tangent line. In the example given, the value is 0.4. The economic interpretation is, by selecting the point A as giving the optimal set, society is willing to give up at the margin one dollar of national income for two and one-half dollars of net regional income. These are used as coefficients of the benefit cost ratios as shown below.

$$BCR = \frac{1(B_n) + 0.4(B_r)}{1(C_n) + 0.4(C_r)} \tag{3-5}$$

where

B_n = national income benefits,

B_r = regional income benefits,

C_n = national costs, and

C_r = regional costs.

For cases where there are more than two objectives Equation (3-5) can be extended with the derived appropriate weights. Major's suggestion requires that all objectives have to be quantified in monetary units and in terms of benefits and costs.

McGaughey and Thorbecke's Approach. The method formulated by McGaughey and Thorbeck (26) is a ranking procedure. The ranking method uses four classes of investment criteria to rank eleven irrigation projects; namely, 1) the benefit-cost ratio, (2) the social marginal productivity of investment, (3) the internal rate of return, and (4) three simple partial investment criteria, the output-investment ratio, the labor investment ratio and the foreign exchange

earnings-investment ratio. Each ratio is calculated from the present discounted values of the projects.

Priorities among the eleven projects is determined on the basis of their contribution to the objectives represented by the investment criteria. Two ranking schemes are used, one ordinal and the second cardinal. A ranking according to the value of the appropriate investment criterion, reflecting each macroeconomic objective, gives an ordinal ranking. The objective of national income is measured by the benefit-cost ratio and the social marginal productivity of investment. For the eleven projects in McGaughey and Thorbeck's example the mean ordinal ranking between the SMP and BCR gives the final ordinal ranking. The same approach is taken for the balance of payment objectives; namely, a mean ordinal ranking between the foreign exchange-investment ratio and the balance of payment component of the SMP. Similarly the employment objective is measured by the employment-investment ratio, and a ranking based on the magnitude of the ratio gives the ordinal ranking.

The second ranking scheme is a cardinal approach. In this method, a ratio of the value of each project's performance for any given investment criterion to the mean value of all projects for the same criterion is computed. For example, the cardinal magnitude for the benefit-cost ratio criteria is

$$\overline{BCR}_j = \frac{BCR_j}{\sum\limits_{j=1}^{n} BCR_j / N} \tag{3-6}$$

where

$j = 1, 2, \ldots, N$ projects, and

$BCR_j = BCR$ for project j.

Similarly the cardinal values of the other criterion are computed and ranked. In the Peruvian irrigation problem, the three macroeconomic objectives of national income, employment and balance of payment are ranked ordinally by Y_j, E_j, and B_j, respectively, and cardinally by $\overline{Y}_j$, $\overline{E}_j$, and $\overline{B}_j$. The three macroeconomic objectives are then related with a weighted linear function. The weighted contributions to the major national goals are determined for both the ordinal and cardinal rule, respectively, by the equations

$$R_j = y\, Y_j + b\, B_j + e\, E_j \qquad\qquad (3\text{-}7)$$

$$\overline{R}_j = y\, \overline{Y}_j + b\, \overline{B}_j + e\, \overline{E}_j$$

where y, b, and e are the normalized relative weights. A final weighted ranking is then defined for each set of weights. In their example, the authors use four sets of weights to determine the sensitivity of the selection process to variations in weights.

McGaughey and Thorbecke utilized various weights in ranking the projects. The various sets of weights are not necessarily the ones which reflect society's opinion. No attempt was made to incorporate in the derivation of the weights society's desires.

Priority Formula. The priority formula was used in the Philippines and Ceylon for a number of years. Higgens (16) formulated the formula for Ceylon and it is similar to the Philippines priority formula. The Philippines formula starts with a derivation of an

industrial priority (IP) equation of the form

$$IP = R_1 + R_2 + R_3 + R_4 \qquad (3-9)$$

where

R_1 = net contribution of the project to national income,

R_2 = the impact of the balance of payments,

R_3 = a measure of the degree of domestic raw materials used in the project, and

R_4 = the impact on employment.

The contribution of the project to national income is

$$R_1 = \frac{E(w + r + i + p)}{K} \qquad (3-10)$$

where

w = wages and salaries,

r = rent for land and buildings,

i = interest paid on capital,

p = profits,

K = total investment of the project, and

E = the essentiality factor.

$(w + r + i + p)$ is the total output of the project. The essentiality factor is primarily a weighting factor. It ranges from 0.5 to 2.5. Projects whose products are exportable or used as inputs to other industries are assigned a value of 2.5, while projects which produce semifinished goods for export are assigned a value of 2, etc.

The balance of payment impact is defined by

$$R_2 = \frac{FE_{s/e} - FE_c}{K} \qquad (3-11)$$

where

$FE_{s/e}$ = foreign exchange saved or earned, and

FE_c = foreign exchange cost.

The measure of the domestic raw material used is defined by

$$R_3 = \frac{0.5(\text{rmd}/\text{rmt})\text{rmd}}{K} \qquad (3\text{-}12)$$

where

rmd = value of domestic raw materials used, and

rmt = value of total (domestic and foreign) raw materials in an

investment.

The value of foreign raw material is also expressed in R_2 as

foreign exchange lost. To avoid this double counting 0.5 is used as an

adjustment factor.

The last objective, employment is computed by

$$R_4 = \frac{d(2000)}{K} \qquad (3\text{-}13)$$

where

d = represents the number of domestic workers employed by the

project.

The 2000 is the legal minimum wage for unskilled workers in the

Philippines. All workers are valued at a rate applicable to the

unskilled workers, irrespective of their actual wage rate. The

priority formula can be used more effectively if statistical data is

available for the country.

The literature on multiple objectives is relatively new and

considerable work is needed to further the theory and to do empirical

analysis. Empirical analysis is very essential in order to gain an

insight into the dynamic relation of the many economic variables. The

following chapters consider a method of project evaluation with multiple macroeconomic objectives. This method builds on Eckstein's argument that an earnest effort must be made to design a means of interpreting the desires of the society and express them analytically in an objective function. Decision models must then be developed which will reveal explicitly what actions will maximize the achievement of specified objectives. If the preferences of the society can be expressed in terms of explicit weights, then the consequences of such weights can be clearly seen and understood. If the result of these weights are found to be desirable, then they can be used again, or if it is not, the required adjustments are easier to make.

Chapter IV develops a weighting scheme and these results are used as the coefficients of the model presented in Chapter V.

CHAPTER IV

DEVELOPMENT OF THE COEFFICIENTS OF THE MODEL

This chapter is concerned with identifying an efficient and
reliable method for human judgement about the relative values of
multiple attributes. Multiple attributes in this study is synonymous
with multiple goals, multiple criteria, multiple objectives or multi-
dimensionality. They are used interchangeably to mean the same thing.
The need for such an approach has been shown in the last chapters. It
has been argued by many that using human judgement to arrive at relative
values of multiple goals is not objective, consistent and mainly biased.
But the same people do accept the fact that the human element is an
important factor. The problem is to design a method which will
minimize the bias and inconsistency and which will achieve a result
that reflects the true characteristics of the environment. An
elementary introduction of the weighting scheme is presented first.
Then the required organizational structure and staffing is discussed
along with all the supporting services and activities. In the last
section a detailed presentation of the weighting approach is presented
subject to the organizational structure and staff.

Preliminary Introduction

The methodology developed here has some common features with the
one formulated by Churchman and Ackoff (8) for business decision making.

The process of assigning relative values to goals is achieved through a group interaction. Individual judgement deviations are corrected through the use of the delphi method where panel consensus is obtained from the opinions of experts (9). A list of attributes will be presented to decision maker J who proceeds as follows:

a) J ranks all the criteria according to his own assessment.

b) He tentatively assigns the value (W_1) 1.0 to the most important criterion, and continues assigning values (W_i) between 0 and 1 to the other criteria according to the ranking.

c) J now compares the criterion assigned value 1.0 with all the other criteria combined. If the criteria assigned 1 is more important than all the rest, the value of 1 is adjusted to reflect

$$W_1 > \sum_{i=2}^{n} W_i$$

d) He picks the second ranked criteria and compares it with the criteria combined and proceeds as in c.

e) J continues until n-1 criteria have been evaluated.

This is a preliminary introduction of the method. A full presentation is provided later. The purpose here is to establish the basis for further discussion.

Policy, Organization, and Goals

In general, governments appreciate the critical importance of sound policy formulation and effective execution for the implementation of their development plan. Together with the right manpower and

institutional arrangement, policy is perhaps the most important aspect
of the development process. Often, it can do more for development than
large amounts of public investments or developmental expenditures,
however well they are planned. The assignment of relative weights to
social, economic development objectives is a matter of policy. It sets
the tone and direction of economic development. This fact makes it
essential that the assignment of such values be made by the highest
possible body of government.

Organizational Requirements

To initiate and coordinate policy at the top level and to lay down
guidelines for a course of economic development, it is proposed in
Chapter III to establish a Central Economic Planning Board (CEPB). The
membership of this Board is outlined and its responsibility to the
council of ministers is established. The CEPB is a policy making body
in the area of economic development. Another organizational requirement
mentioned in Chapter III is the creation of a planning and programming
unit (PPU) in the different government operating agencies. The
function of the PPU is to identify and screen projects within the
operating area of the respective agency, and to coordinate closely the
work of the agency with the Ministry of Planning and Economic Develop-
ment (MPED) which overlooks all projects under the governments juris-
diction. The MPED is responsible for compiling a manual containing
pertinent statistical data, definitions of objectives and terms, past
decisions, status of the economy, changes in the economy due to past
decisions of the Board, future trend and prediction of the economy,
and the likely impact each objective is going to have on the central

economic development plan. This manual referred to as Manual I is mostly for the staff of the planning and programming unit of each ministry and agency. This manual will serve as a link between such units who are responsible for initiating projects within their specific areas and the MPED which is the national coordinator. A second manual (Manual II) should be prepared for the members of CEPB. It contains information on definitions of terms and objectives, detailed instructions on the weighting of objectives and other pertinent information. The members of the CEPB, through their PPU of their respective ministry or agency should be aware of the economic conditions, direction the nation is taking and the economic aspirations of the nation. This prepares the members of the CEPB to undertake one of the most important functions of the board; namely, the definition of the true economic values of each objective listed. The method through which the Board assigns such economic weights is describer here.

Valuation of Economic Objectives

At this stage, the MPED has oriented the members of the CEPB through seminars and other media about the objectives (goals) of the nation related to economic development. Accordingly the Board has agreed on the objectives to be considered. These objectives are assumed to be the same ones listed in Chapter II. For reference, the objectives are repeated below:

1) Maximize national income.

2) Maximize employment.

3) Maximize foreign exchange earnings.

4) An equitable distribution of income among all regions.

The Board is responsible for setting the value the government is going

to attach to each objective. It is the MPED's responsibility to design

the mechanics by which these weights are obtained. The mechanics of

the method are discussed below using the four national objectives

previously listed. These weights are actually the coefficients of the

objectives in the model developed in the next chapter.

Procedure I

Step 1. Each member of the CEPB ranks the three objectives:

national income, employment, and balance of payment. (The fourth

objective is not included here because income distribution is entered

in the model as a separate variable for each region. Hence the

different economic regions have to be weighted in the same manner as

the three objectives.) If national income is the most important it will

be ranked as 1 and so on.

Step 2. The individual rankings are compared. If deviations

exist in the ranking, each individual must support his ranking. These

anonymously supporting arguments and the ranking summary are given back

to the members. Members are encouraged to ask for clarification or for

any additional information. The objectives are re-ranked for the second

time. If consistency among the members in ranking the objectives is

not achieved, the experts of the MPED should then study the ranking and

the reasons why each member ranked the way he did, and present a summary

and their recommendations. The Board is then asked to re-rank the

objectives. If there are still variations, the chairman will conduct

a vote and a ranking will be determined.

Procedure II

Step 1. Each member will assign a value of one (W_1) to his choice of the most valued objective. He then assigns a value to all other objectives. Each member then will have a table similar to the hypothetical example shown in Table III.

TABLE III

RANKING AND ASSIGNMENT OF VALUES

Objectives	Rank	Value (W_i)
National Income	1	1
Employment	2	.8
Balance of payment	3	.5

The value assigned by each member will, normally, be different except the one assigned to the most important objective $W_1 = 1$. It is important that the Board agree on the evaluation step by step. This means that the variation in the value assignment must be corrected at each stage. The method used to correct such deviation is the delphi method of estimating. Each individual's evaluation is marked on a quantitative interval scale as shown below for the employment objective.

W_{E1} $\quad W_{E2}$ $\quad W_{E3}$ $\quad W_{E4}$ $\quad W_{E5}$ $\quad W_{E6}$ $\quad W_{E7}$ $\quad W_{E8}$
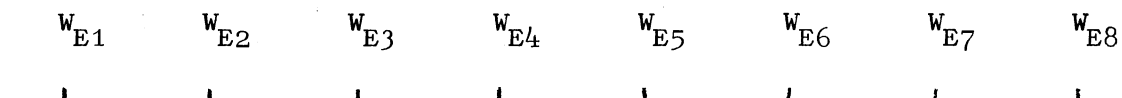
Where, for example, W_{E3} stands for the value Individual 3 assigned to

the employment objective. The MPED experts must study why extreme

values are assigned by some members. A discussion will be held and an

attempt will be made to narrow the range. The assumption here is, if

all members understand the objectives and their impact on the economy,

their evaluations should arrive at a unique value. Hence using the

delphi method, the median (M), upper quartile (Q_U), and lower quartile

(Q_L) is calculated and marked on the quantity interval scale. Each

individual whose evaluation falls outside the lower and upper quartile,

will be asked.

$$W_{E1} \qquad W_{E2} \qquad W_{E3} \qquad W_{E4} \qquad W_{E5} \qquad W_{E6} \qquad W_{E7} \qquad W_{E8}$$

$$Q_L \qquad\qquad\qquad\qquad M \qquad\qquad\qquad\qquad Q_L$$
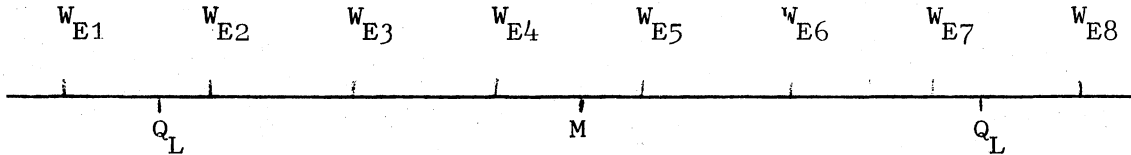
to state briefly the reason for their evaluation. All this exercise is

done anonymously. These reasons are then communicated to the board

with the median, upper and lower quartile.

Step 2. Each member is then asked to reconsider his estimation

with the additional information. The second estimations are then

displayed again on a quantity interval scale with the new median, upper

and lower quartiles. If any of the evaluators' estimation lies outside

the interquartiles of the first estimate they are asked to state why the

$$W_{E1} \qquad W_{E2} \qquad W_{E3} \qquad W_{E4} \qquad W_{E5} \qquad W_{E6} \qquad W_{E7} \qquad W_{E8}$$

$$Q_L \qquad\qquad\qquad\qquad M \qquad\qquad\qquad\qquad Q_L$$
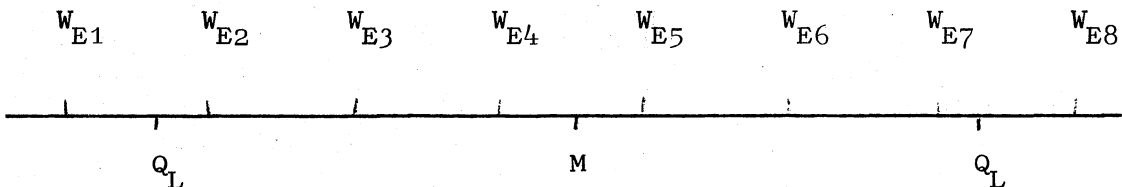
estimate is lower or higher than corresponds to the 75% majority

opinion expressed in the first round of estimation. The result of the

second round are usually less dispersed than the first. The result of
the second estimation together with the individual opinions are then
communicated to the Board.

Step 3. Continue step 2 until necessary. If at the end of the
exercise there is still variation in the estimate then a compromise
is obtained. The compromise depends on the frequency distributions of
the estimates. The objective of this exercise is to satisfy the
maximum number of estimators. Three possible values can be obtained
statistically which approximates the correct value. These are the
median, mode, or mean. In each case all three values will be calcu-
lated, and the following criteria is used.

    1)   If the frequency distribution is such that one of the values

           is frequented by the majority, then the mode is used.

           Ex. Assume that the eight members of the CEPB narrowed

               their estimates to the following:

                    0.6, 0.6, 0.6, 0.6, 0.6, 016, 0.5, 0.5

               In this case the satisfaction of the majority is

               achieved by taking the mode which in this case is 0.6.

    2)   If the estimated values are distributed in such a way that no

           one estimate is repeated by a majority, then the mean is

           calculated:

           Ex.   0.3, 0.4, 0.5, 0.5, 0.6, 0.7, 0.7, 0.8

           The mean is 0.5 and is assumed to satisfy the majority. In

           such cases the median can also serve as an approximate value.

           The median is 0.55 in this case. Such dispersion in

           estimated values are very rare in practice. Successive

           re-ranking tend to make the estimates have distributions like

case 1. The applicability of the delphi technique in public decisions have been demonstrated in many cases. Documents supporting the viability of the delphi technique in public decisions are given in the bibliography.

Step 4. Repeat the weight assignment (steps 1, 2, and 3) for the rest of the objectives.

Step 5. Record the result in a table form. A sample is shown below.

TABLE IV

FINAL ASSIGNMENT OF WEIGHTS

Objectives	Rank	(W_i) Value (corrected)
National Income	1	1.0
Employment	2	0.7
Balance of Payment	3	0.4

Assuming there are four economic Regions, the income distribution objective is ranked and weighted against each competing region just in the same fashion as the three objectives (income, employment, and foreign exchange). The result is tabulated in Table V.

TABLE V

REGIONAL ECONOMIC WEIGHTS

Regions	Rank	(W_i) Value (Corrected)
I	3	0.5
II	4	0.2
III	1	1.0
IV	2	0.8

Procedure III

Procedure III provides a measure of relativeness. Each objective was assigned a value (W_i) independent of each other. The project analysts are interested in the relative value of each objective or each region when income distribution is considered. This procedure introduces successive comparison as a means of establishing relative values.

Step 1. Compare the highest ranked objective (region when income distribution is considered) to the rest of the objectives (regions) combined as one. In the case of the first three objectives compare national income to employment and balance of payment and in the case of income distribution compare Region III to Regions (I + II + IV).

Conditions:

a) If Region III is found to be more important than Regions (I + II + IV) then the value of W_3 must be adusted such that the following relationship is true

$$W_3 > W_1 + W_2 + W_4$$

(Only W_3 would be changed without altering the right hand side.)

b)   If Region III is equally preferred to Regions (I + II + IV), then adjust W_3 such that

$$W_3 = W_1 + W_2 + W_4$$

c)   If Region III is preferred less than Regions (I + II + IV) drop the lowest valued region and compare Region III with Region (I + IV). If condition (a) is the case then W_3 is adjusted such that

$$W_3 > W_1 + W_4$$

If condition (b) is the case adjust W_3 such that

$$W_3 = W_1 + W_4$$

If Region III is preferred less than Region (I + IV), continue dropping the lowest valued region until Region II is preferred or until Region III is compared with the top two Regions, that is the regions ranked second and third. This step assigns a value to the highest ranked region.

Step 2. Compare the second highest ranked region to the rest of the regions combined as one. The process of comparison described in step 1 is repeated. A relative value is thus assigned to the second highest ranked region.

Step 3. Continue steps 1 and 2 until the third objective from the bottom is compared to the last two objectives.

Procedure IV

Normalize the adjusted relative values by dividing each value by ΣW_i. These normalized values are represented by W_i'

$$W_1' = W_i / \sum_{i=1}^{n} W_i$$

The procedure of assigning relative weights is described here with a specific problem. The procedure is presented in Figure 5 using general notations. This approach assumes certain characteristics that need to be stated for clarity and understanding.

1) For every goal G_i, there occurs a non-negative W_i which estimates the relative value of the goal to the rest in the set.

2) If G_m is more valued than G_n then it follows that $W_m > W_n$ and if G_m and G_n are equally valued then $W_m = W_n$.

3) If W_m and W_n correspond to G_m and G_n then $W_m + W_n$ corresponds to the combined outcome of G_m and G_n. This is the additive assumption.

3a) If G_m is preferred to G_n, and G_n is preferred to G_q then the combined output of G_m and G_n is preferred to G_q.

3b) The value assigned to the combined outcome of G_m-and-G_n is the same to that assigned to G_n and G_m. The order of presentation does not have any effect on the importance of the objective.

3c) If the combination of G_m and G_n is equally preferred to G_n, then $W_m = 0$.

PROC. I

RANK OBJECTIVES IN
ORDER OF IMPORTANCE

ALL RANKING SAME
GO TO PROC. III

RANKING NOT SAME
RERANK/VOTE

PROC. II

ASSIGN W_i ($0 \leq W_i \leq 1$)
ASSIGN 1 TO THE OBJ.
RANKED 1. CONTINUE

IF NOT CALCULATE Q_i,
M, Q_U AND REQUEST
REASONS FROM ALL

COMMUNICATE REASONS
AND REQUEST SECOND
EVALUATION

ASSIGNMENT OF ALL
MEMBERS SAME, GO
TO PROC. III

REPEAT UNTIL ASSIGN-
MENT IS ACCEPTABLE

REPEAT THE PROCESS
FOR ALL OBJECTIVES

Figure 5. Flow Chart of Successive Evaluation

PROC. III

COMPARE
O_1 TO $O_2 + O_3 + \cdots + O_N$

O_1 AND $O_2 + O_3 + \cdots + O_N$ EQUALLY PREFERRED ADJUST W_1 SUCH THAT $W_1 = W_2 + W_3 + \cdots + W_N$

$O_1 + O_2 + \cdots + O_N$ IS PREFERRED. COMPARE O_1 TO $O_2 + O_3 + \cdots + O_{N-1}$

O_1 IS PREFERRED ADJUST W_1 SUCH THAT $W_1 > W_2 + W_3 + \cdots + W_N$

O_1 IS PREFERRED ADJUST W SUCH THAT $W_1 > W_2 + W_3 + \cdots + W_{N-1}$

O_1 AND $O_2 + \cdots + O_{N-1}$ EQUALLY PREFERRED ADJUST THAT $W_1 = W_2 + \cdots + W_{N-1}$

O_1 NOT PREFERRED COMPARE O_1 TO $O_2 + \cdots + O_{N-2}$, ETC. UNTIL O_1 IS PREF. OR O_1 COMPARED TO $O_2 + O_3$

PROC. IV

COMPARE O_2 TO $O_3 + O_4 + \cdots + O_N$ AND PROCEED AS PROC. III

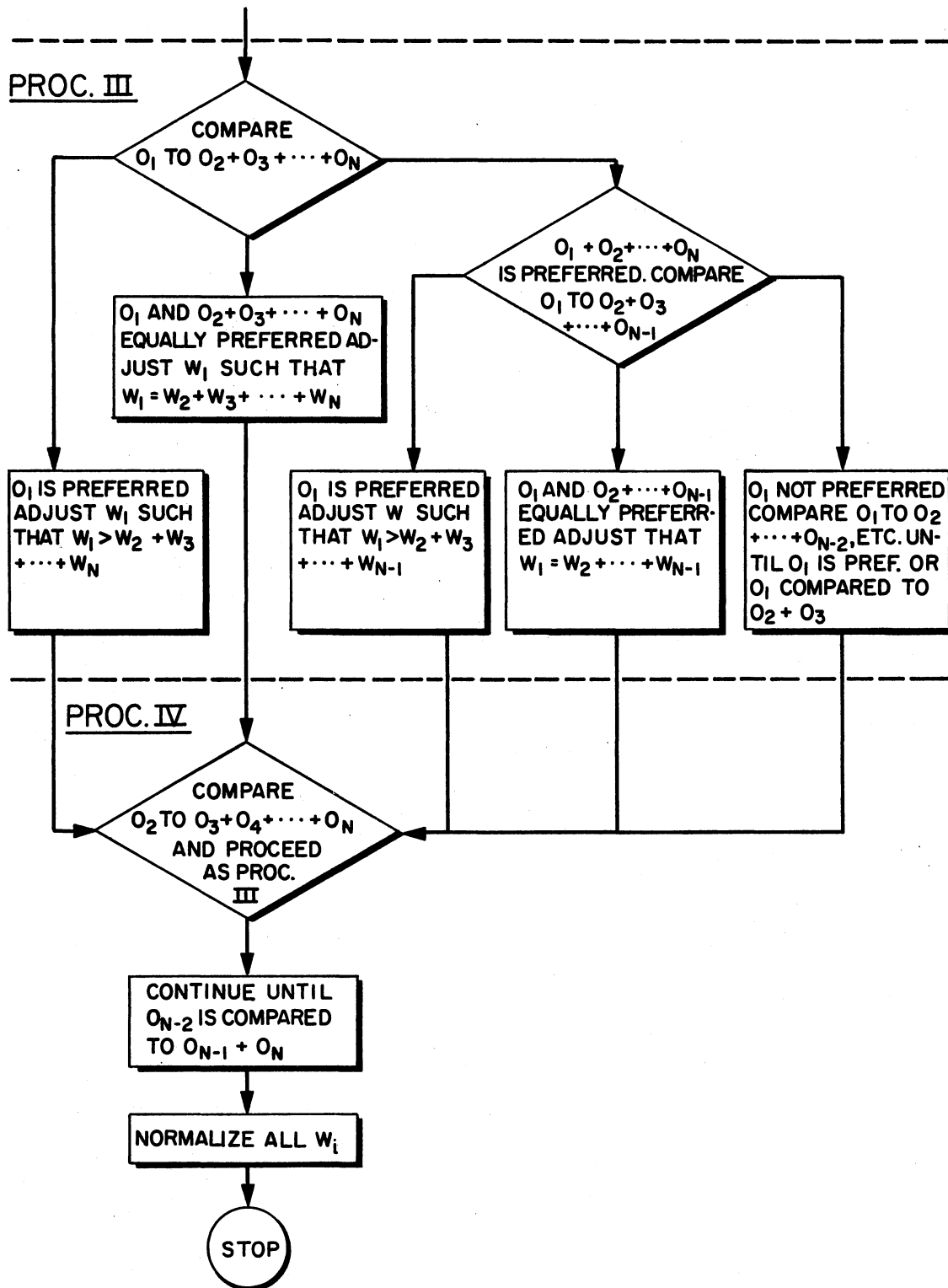CONTINUE UNTIL O_{N-2} IS COMPARED TO $O_{N-1} + O_N$

NORMALIZE ALL W_i

STOP

Figure 5. (Continued)

4) This procedure assumes also that each member of the board

has received at least the minimum information about the

scheme, the objectives, their meaning, and other pertinent

matters such that there is a required minimum standard of

knowledge that exists among the members.

The formation of weights to be used as coefficients of attributes

implies that the attributes are measurable numerically in a comparable

form so that they can be multiplied by the weights, and then summed

into a weighted average. MacCrimmon (24) argues that the attributes

have to be comparable because the model combines across attributes,

a 'high' value for one attribute must receive approximately the same

numerical value as 'high' values of other attributes. This is taken

care of in the next chapter where the measure of effectiveness of each

objective is developed and the model formulated.

CHAPTER V

THE MULTIPLE-ATTRIBUTE MODEL

This chapter is concerned with the formulation of a multiple-
attribute model for project selection. It incorporates the selection
of appropriate investment criteria measuring the contribution of each
project to the distinct national targets set by the government of the
particular nation. It is unreasonable and illogical to use a single
attribute (objective) model for the allocation of public funds to
development projects. Yet most of present day decisions are taken on
this supposition. The traditional capital budgeting objective of
maximizing net present value, maximizing expected utility, decision
rules such as minimizing costs are over-simplifications of the rather
complex problems facing decision makers. The single objective model
is still popular among private corporation executives. Their belief
is reinforced by acadamicians such as Van Horn who argue that the
objective of a corporation is to maximize the wealth of the present
stockholders (38). Such statements overemphasize economic efficiency
and profits. Lee and Lerro (20) write that, "the primary deficiency
of contemporary decision analysis has been the inability to assimilate
multiple objectives." The existence of multiple conflicting objectives
in the private sector has been dealt with by many authors. Appropriate
references will be given for these cases in the bibliography.

In the public sector of the economy, it is much easier to identify multiple, conflicting social objectives. The justification and logic of the goals are more evident. Economic development means different things to different people within a country. Even economists cannot come up with one identical definition. A general motive of economic development plan can be stated as the maximizing of the social welfare of the people. This statement is so broad that a consensus interpretation is almost impossible. For the purpose of this study a program of economic development is defined as a plan of action which would seek to maximize collective satisfaction of relevant, multiple, conflicting social objectives.

Social Objectives

The social objectives which must be defined for the multiple-attribute model relate to needs which can be satisfied by a program, a plan of action of economic development. Bryce (3) writes that "the soundest and most important reason for embarking on a program of industrialization is that it may be a way to increase the national income of the country." This proposition is analogus to the central theme of capital budgeting in the private sector. Maximization of the wealth of the stockholders is the most important objective in capital budgeting. In the public sector the citizens could be viewed as the stockholders and the nation as the corporation. Projects which can bring a net gain to the national income provided they meet some other criterion, discussed below, are acceptable. Stated differently, investment projects should, as a minimum requirement, support themselves.

A second major objective of economic development is employment of the unemployed and underemployed. One of the characteristics of underdeveloped nations is unemployment and/or underemployment. This was discussed adequately in Chapter II. Underdeveloped nations have a vast resource of untapped manpower. This resource is an important economic element, and unemployment and underemployment are indications that a valuable economic resource is being wasted. Different investment projects have different employment implications which require a clear understanding about the relevance of employment creation as a goal to be pursued by planners. Investment projects are either capital intensive (technologically sophisticated, automated, and employing a very small number of people) or labor intensive (not highly automated and employing a large number of people). The capital intensive projects minimize employment but are highly economical, thus contributing to the national income. The labor intensive projects do not contribute as much in net gain to the national income but provide employment to a large segment of the population. These are the conflicts that have to be resolved if the right decision is to be taken.

A third major objective is the balance of payments. An investment project's positive contribution to the balance of payments in the form of import substitution or exportable products could have an extremely important impact on the overall economic development. Some well-planned projects can substantially improve the balance of payment situation, while others lead to deterioration. A good number of the underdeveloped nations which import agricultural produce such as wheat, corn, etc., for local consumption can save a good portion of the total foreign exchange expenditure by investing on a thoroughly-studied irrigation

and fertilizer project. One of the basic reasons that developing

nations depend on foreign aid is the shortage of foreign exchange.

A surplus of foreign exchange would make it possible for a developing

nation to buy the technologies and heavy machinery which are so vital

for a nation's development. Investment projects are often expected to

improve the foreign exchange position of a nation or leave it in the

same position it was.

A fourth objective of economic development is the distribution of

income. At first glance it might be assumed that if employment is

maximized, the income distribution objective becomes redundant. It is

not exactly so. In many underdeveloped countries all the potential

employment opportunities are concentrated in one urban area. Regional

economic disparity exists. Even though projects which maximize employ-

ment are adopted, their location makes the income distribution

objective vulnerable. An economic development plan is meant to be for

the entire country, not for one urban area.

The collection of the relevant social objectives which were formu-

lated in Chapter III are summarized below.

1) Maximization of national income,

2) Maximization of employment,

3) Maximization of the net earnings of foreign exchange, and

4) An equitable distribution of income among all regions.

This list of objectives is not meant to be exhaustive. It touches

the most important and far reaching ones. Some of the frequently listed

objectives that are not listed here are left out since most are means

to an end and not an end by themselves.

Such listings of objectives do not set them in the sense required
for derivation of operational criteria in project analysis. The
relative importance and implications of the various objectives must be
specified, and to be useful in the planning process, the specifications
must be quantitative. The process through which this could be achieved
was discussed in Chapter IV in some detail. The need for such a
laborious exercise as described in Chapter IV is based on the belief
that a careful evaluation of goal weighting would contribute to
minimizing the risk associated with the allocation of public funds.
The demand for economically good and socially sound projects can not be
overemphasized. Hence the process of policy formulation, such as
arriving at economic weights was done through a rational and logical
scheme where a democratic and free thinking atmosphere was prevailing.

The formulation of such a policy (assignment of weights) by the
CEPB completes the first stage of the project analysis activity. The
staff experts of the MPED and the PPU team of each ministry are now
equipped with an important policy that will guide their efforts.

Project Evaluation Criteria

The purpose of public fund investment in various projects is to
achieve a higher rate of economic growth. Economic growth or economic
development have been defined earlier in this study as a process which
seeks to optimize a collective satisfaction of relevant economic,
social objectives. The question now becomes, how do project analysts
assess the contribution each project makes towards each of the social
objectives. The evaluation criteria for each objective is developed
below.

Measures of Effectiveness

National Income. The most elementary approach in any economic evaluation is to make a comparison between, the positive future earnings of a project (benefits), and expenditures both initial and during the project's operation (cost), without any consideration for the timing of the benefits and costs. Such an approach implicitly assumes equal weights for benefits and costs which occur at different time periods. This assumption has been subjected to a considerable amount of theoretical discussion during the last few years. Techniques have been developed to incorporate the time value of money. The approach taken here builds on the concept of net present value.

As indicated in Chapter II, all capital investments are undertaken by the government in a centrally planned economy. Because of this fact and the characteristics presented in Chapter II, the following assumptions are essential for the development of the model.

A) Since governments are investing public funds, all benefits are considered to go to the general public.

B) Projects are selected under only one criteria--maximization of a collective satisfaction of relevant social objectives.

C) Projects which are non-economic or non-contributing to development (ex., prestige, political) are outside the scope of this study.

The measure of effectiveness of project contribution to national income; namely, net present social value is defined as the algebraic discounted sum of all the positive returns and negative returns--initial and during project operation. Positive returns include the sale of any

building and equipment remaining at the termination of the project.

Negative returns include all expenditures on goods and services during

the year in which they are incurred. These returns, both positive and

negative, are then discounted to the present at the appropriate social

discount rate. An approach to the development of the social discount

rate will be presented in a later section. The definition of the net

present social value (NPSV) is identical to that of the net present

value (NPV) except for the method in which the numerical values of the

benefits and costs are arrived at. Mathematically the NPSV is

$$NPSV_j = \sum_{t=0}^{N} [(B_{t_j} - C_{t_j}) \beta^{-t} - K_{t_j} \beta^{-t}] \qquad (5\text{-}1)$$

where,

K_{t_j} = capital investment in project j at year t,

B_t = benefit (positive return) from project j at time t,

C_t = expenditure (operating) attributed to project j at time t,

N = the life of the project,

$\beta = (1 + i_s)$ (the discount factor), and

i_s = the social rate of discount.

When NPV is calculated for a particular project in the private

sector, the benefits and costs are entered at the market price. In the

case of NPSV, the market price does not reflect the true social value

of the benefits and costs associated with the project. The best

approximation of the benefits and costs of a public project to the

public is the shadow price. The shadow price is the price which the

economist attributes to goods or services on the grounds that it is

more appropriate for the purpose of economic evaluation due to market

price inequities in underdeveloped nations. It is in essence the price which will occur if and only if a perfectly competitive market equilibrium exists. A mathematical explanation of the shadow price will shed more light on the concept. Consider a simple linear programming problem where an objective function is maximized subject to certain amounts of inputs and a number of technologically feasible factor-combinations. From this "primal" problem, a "dual" problem can be derived having a corresponding objective function which is to be minimized. It transpires that, for a wide class of problems, the variables in the dual solution can be interpreted as shadow prices, inasmuch as they are the correct input prices consistent with the maximum value of the primal objective function. The value of the dual function is the minimum input cost, subject to the constraints and to the requirement that no profits be made. These shadow prices are, therefore, no different from the goods and services prices that would emerge in a perfectly competitive equilibrium in which product prices are exogenously determined. A very clear introductory presentation of the concept of the primal and dual formulation of linear programming can be found in Shamblin and Stevens (32).

The development of Equation (5-1) does not need any elaboration. It has been dealt with by many authors. Appropriate references are provided in the bibliography.

Employment Objectives. In the discussion in Chapter II of the characteristics of underdeveloped nations, the relevance of employment in the total economic development package has been presented. Experience has shown that the objective of employment creation is a goal which fully exploits the production potential of a nation.

Governments have two possible alternative policies to follow--employment

for employment's sake, or employment as a means to the objective of

production; that is, an increase in employment results in an increase

in production. This thesis adopts the latter policy. In the long run,

the employment objective is best served if a policy of productive

employment is instituted from the very beginning.

The measure of effectiveness of the employment objective is

computed by the total realizable income which the semi-skilled and

unskilled employees earn during the operation of the project. The

earnings can be calculated from the minimum wage proclaimed by law,

assuming the existence of such a law in the developing nations. The

International Labor Organization (ILO) has been a driving force in most

developing nations behind such laws, but adherence to the laws in most

developing nations is questionable.

Let the minimum wage per year of a semi-skilled worker be γ_1 and

that of the unskilled worker be γ_2.

Assume that in project j there are L_{1_j} and L_{2_j} semi-skilled and

unskilled workers, respectively. Then the total realizable income per

year (TRI) is

$$TRI = \gamma_1 L_{1_j} + \gamma_2 L_{2_j} \qquad (5\text{-}2)$$

For a project life of N years, the present total realizable income

(PTRI$_j$) from project j is

$$PTRI_j = \sum_{t=0}^{N} (\gamma_1 L_{1_j} + \gamma_2 L_{2_j}) \beta^{-t} \qquad (5\text{-}3)$$

where,

$\beta = (1 + i_s)$, and

i_s = social rate of discount.

$PTRI_j$ can be considered as project j's contribution to the direct income of the society.

Balance of Payments Objective. The objective of balance of payments will be measured by a project's earning power of foreign exchange. A project might contribute to the balance of payments objective either through reducing imports (import substitution) or earning foreign exchange through exportable products.

Let the foreign exchange saved by project j through import substitution be F_{s_j}, foreign exchange earned through export be F_{E_j} and foreign exchange spent due to project j be F_{o_j}. The total foreign exchange earning power of project j per year ($FEEP_j$) is

$$FEEP_j = F_{s_j} + F_{E_j} - F_{o_j} \tag{5-4}$$

For a project life of N years, the present foreign exchange earning power of project j ($PFEEP_j$) is

$$PFEEP_j = \sum_{t=0}^{N} (F_{s_j} + F_{E_j} - F_{o_j}) \beta^{-t} \tag{5-5}$$

where,

$\beta = (1 + i_s)$, and

i_s = social rate of discount.

$PFEEP_j$, then measures the foreign exchange earning power discounted to the present.

Equations 5-1, 5-3, and 5-5 are measures of the effectiveness of national income, employment and balance of payment objectives.

Income Distribution Objective. This objective is designed to correct any regional economic development disparity. Regional equity in development can be effected logically through a careful choice of project location. The value of project contribution in region X and Y can be different, depending on the development stage of each region. Assuming region X to be far more developed than region Y, the location of a project in region Y will have a higher impact on the people in region Y than it would on the people in region X had it been located in region X. The question now becomes how much higher is the impact on region Y. In other words, the value of a one-hundred-dollar benefit in region X is valued $(100 + \varkappa)$ dollars in region Y. How can the project analyst determine the extra value $\varkappa$?

In principle this is a policy matter that has to be decided by the CEPB. The country should be divided into economic regions according to the stage of development. The CEPB will then assign economic weights for each region using the successive evaluation technique developed in Chapter IV. The economic weight of region r is denoted by I_r.

In Chapter III, social welfare was given as a function of four variables. Reproducing Equation (3-3b),

$$\text{Social Welfare (SW)} = f(\text{national income, employment, balance of payment, income distribution}) \qquad (3\text{-}3b)$$

In notation form, the equation simplifies to

$$SW = f(NPSV, PTRI, PFEEP, I)$$

Equations (5-1), (5-3), and (5-5) and the regional economic weight together with the appropriate weights for each objective determine the project's contribution to the social welfare. The maximization of

these aggregate social objectives, subject to physical and economical

constraints, gives an optimum result. The objective function of the

model defined as the weighted sum of each criteria adjusted for income

distribution is identified as "PROJECT VALUE" (PV). In general, the PV

of project j located in region r is given by Equation (5-6)

$$PV_{jr} = I_r \left[W_i \sum_{t=0}^{N} \left\{ (B_{j_t} - C_{j_t}) \beta^{-t} - K_{j_t} \beta^{-t} \right\} + W_2 \sum_{t=0}^{N} (\gamma_1 L_{1j_t} + \gamma_2 L_{2j_t}) \beta^{-t} \right.$$

$$\left. + W_3 \sum_{t=0}^{N} (F_{s_{j_t}} + F_{e_{j_t}} - F_{o_{j_t}}) \beta^{-t} \right] \tag{5-6}$$

All the variables are as defined in earlier sections.

W_1, W_2, and W_3 = economic weights of national income, employment

and balance of payment objectives, respectively.

The general public fund allocation model for an M set of projects and Q

economic regions using multiple macroeconomic objectives is to

$$\text{Maximize}_{\forall r,j,t} \sum_{r=1}^{Q} I_r \sum_{j=1}^{M} \left[W_1 \sum_{t=0}^{N} \left\{ (B_{jt} - C_{jt}) \beta^{-t} - K_{jt} \beta^{-t} \right\} + W_2 \sum_{t=1}^{N} (\gamma_1 L_{1j_t} + \gamma_2 L_{2j_t}) \beta^{-t} \right.$$

$$\left. + W_3 \sum_{t=1}^{N} (F_{s_{j_t}} - F_{E_{j_t}} - F_{o_{j_t}}) \beta^{-t} \right] X_{jr} \tag{5-7}$$

$$(t = 0,1,2, \ldots, N; \ j = 1,2,3, \ldots, M;$$

$$r = 1,2, \ldots, Q)$$

Subject to:

$$\sum_{j=1}^{M} K_{jo} X_{jr} \leq DB_o$$

(Development budget constraint with a carry over assumption)

$$\sum_{j=1}^{M} K_{j1} X_{jr} \leq DB_1 + (DB_o - \sum_{j=1}^{M} K_{jo} X_{jr})$$

$$\vdots$$

$$\sum_{j=1}^{M} K_{jN} X_{jr} \leq DB_N + (DB_{N-1} - \sum_{j=1}^{M} K_{j(N-1)} X_{jr}) \tag{5-8}$$

$$X_{11} + X_{12} + \ldots + X_{1Q} + \ldots + X_{3Q} + \ldots + X_{PQ} \leq 1 \text{ (mutually exclusive)}$$

$$\tag{5-9}$$

$$X_{kc} - X_{ld} \leq 0 \ (k \in j, \ 1 \in j)$$

$$(c \in r, \ d \in r) \qquad \text{Dependency} \tag{5-10}$$

$$K_{jt} \geq 0 \tag{5-11}$$

$$X_{jr} = 0,1 \qquad \text{(Indivisibility of projects)} \tag{5-12}$$

where,

B_{j_t} = proceeds of project j in year t,

C_{j_t} = operating expenses of project j in year t,

L_{1j_t} = number of semiskilled employees in project j in year t,

L_{2j_t} = number of unskilled employees in project j in year t,

$F_{s_{j_t}}$ = foreign exchange saved by project j in year t,

$F_{E_{j_t}}$ = foreign exchange earned by project j in year t,

$F_{o_{j_t}}$ = foreign exchange spent by project j in year t,

X_{jr} = project j in region r,

I_r = economic weight of project contribution in region r,

W_1 = economic weight of the national income objective,

W_2 = economic weight of the employment objective,

W_3 = economic weight of the balance of payment objective,

Y_1 = minimum yearly wage of semi-skilled worker,

Y_2 = minimum yearly wage of unskilled worker,

β = $(1 + i_s)$,

i_s = social rate of discount,

K_{j_t} = capital investment in project j in year t, and

DB_t = development budget in year t.

Thus, the problem is one of selecting a subset of project(s) from the entire set of potential projects such that the 'PROJECT VALUE' (5-7) to the nation is maximized subject to the physical and economical constraints (5-8 through 5-12). The set of constraints shown in Equation (5-8) are development budget constraints for each year of project operation. These constraints present a carryover of the remaining budget from last year's operation to this year. The underlying assumption in such cases is that the government will not be considering any new project for the next N years other than the M set of projects being considered now. This makes the government planning a static approach and in many instances is not recommended. It is included in the set of restrictions to make the list complete. In most cases an initial budget constraint replaces (5-8). This has the form

$$\sum_{j=1}^{M} K_{jo} X_{jr} \leq DB$$

A 0-1 integer programming algorithm can be used to solve the maximization problem. Weingartner (39) has an excellent presentation of the algorithm in his book. The solution to the maximization problem is very sensitive to the social discount rate used as is shown in the

numerical example analyzed in Chapter VI. The process of determining

the social discount rate is presented in the next section.

The Social Rate of Discount

The development of the multiple attribute model for project

selection resulted in an objective function which measures the true

value of a project to the general economy subject to the policy set by

the Central Economic Planning Board. The objective function has been

appropriately defined as Project Value. The project value is a

function of two types of parameters: exogenous, which are not the

direct result of the particular project (ex., economic weights, social

rate of discount); and endogenous parameters, which are the direct

result of the project (ex., output or product of each project,

employment creation, etc.). In the previous sections the highlights of

these parameters were discussed except for the social rate of discount,

which this section is about.

The purpose of a social rate of discount is to provide a guide in

decision making. In project selection, no matter what model is used,

the discount rate employed is very important when intertemporal effects

are considered. The selection process is very sensitive to the

particular social discount rate used. A small variation in the social

rate of discount might cause a project to be rejected or accepted.

A project's benefits (income) and costs if discounted at 8% might be

accepted, while at 10% it might be rejected.

Meaning of Social Rate of Discount

Baumol (2) in one of his articles on social rate of discount writes

> ... the social rate of discount for public projects is the one which measures correctly the social opportunity cost. The decision to devote resources to investment in a public project means, given the overall level of employment in the economy, that these resources will become unavailable for use by the private sector. And this transfer should be undertaken whenever a potential project available to the government offers social benefits greater than the loss sustained by removing these resources from private sector (p. 789).

It is obvious that when Baumol wrote this, he had in mind economics where the private sector is developed to such an extent that it is capable of producing projects on its own. Such is the condition in the U.S. and Western Europe, where to a large extent there exists an unplanned economy. In the developing nations, the economy of the private sector is not developed enough to undertake such a program. Entrepreneurship is not developed, and for some time the government has to take the lead and initiative for capital investments. Thus Baumol's principle premise that the private sector is economically competitive is not applicable.

Harberger's definition is acceptable to the basic premise of this study. He writes that "the social rate of discount should be viewed as a measure of the marginal productivity of capital in the economy as a whole" (14). This productivity of capital is nothing but the measure of the opportunity cost of postponement of receipt of any benefit yielded by a public project. Accepting this definition, the analyst is interested in the question of what the important variables are that have to be considered when such a rate is developed. The method of

approach used in this study resembles that of Krutilla and Eckstein (19), that of tracing a) sources of funds, and b) type of projects.

A)   Sources of Funds

The sources of funds available to governments can be classified into two classes; namely, international and domestic.

1)   International Sources

a) Foreign Loans. Much of the progress in economic development due to investments in good projects in the developing nations is credited to capital obtained from this one source. International development loan agencies such as the International Bank for Reconstruction and Development (IBRD), International Monetary Fund (IMF), Overseas Development Agency of England (ODA), Swedish Development Agency (SDA), Agency for International Development of the U.S. (AID), and many others have supplied capital in the form of long-term loans with a reasonable, low interest rate. This interest rate is the cost of raising the capital from such sources. It is then simple economic rule that one would expect a higher return from the project than the cost of capital or at least at the minimum equal to the cost of capital. Therefore $I_s \geq I_c$ (social rate of discount is greater than or equal to the cost of capital). Basically the sources of funds give one element of the social rate of discount; that is the

minimum social rate of discount. The cost of

capital is the minimum to which the opportunity cost

must be added. This introduces a second variable;

namely, the type of project.

b) Foreign Aid. Foreign aid does not have a cost of

capital since the receiving nations do not have to

repay. Even though such a fund is available, when

employed in projects, it is essential to use as a

cost of capital the minimum rate the foreign develop-

ment loan agencies are charging.

2) Domestic Sources

a) Taxation. Taxes can be levied for the purpose of

funding an investment project. In such instances,

the rational employed is that it is in the general

public good to forego any benefit that would have

come, had it not been for the additional tax each

individual had to pay for the sake of the future

benefit from the investment project. The cost of

capital for such a fund is a complex and controversial

case. This study suggests that the cost of capital

should be the rate at which an individual could raise

such a fund. This is the market rate or the rate at

which individuals can borrow from banks. (In most

developing nations the bank rates are controlled by

the National Banks.)

b) Government Bonds. Another possible source of fund

is government bonds. This is one of the many ways the

government encourages the citizens to invest in the

nation's economic development and at the same time

earn a guaranteed return on their investment.

Whatever the rate the government attaches to the

bond, if such funds are used in projects, the cost of

capital is the interest rate on the bond. There are

other sources which are not mentioned here, but to

understand the development concept of the social rate

of discount, these are sufficient.

B) Types of Projects

It was stated earlier that in general the social rate of

discount is greater than or equal to the cost of capital.

The word greater implies a broad interpretation. By how much

greater does the word greater mean? The answer as to exactly

how much greater the social rate of discount should be

depends on the treatment of risk. This study, as mentioned

in the outline, deals with deterministic cases. But as an

introduction to the problem of risk in general, a simplified

version is given here.

An analysis of the types of projects being considered

can give valuable information on the project's riskiness.

Projects can be categorized into three major classes in terms

of their possible contribution.

1) A project can produce products which are exported. This

type of project has a substantial portion of its market

in the world market, where competition is usually stiff.

The factors which affect the project are not limited to

the local conditions only, but to the international

conditions as well. Hence such projects can face a high

degree of risk since some of the factors which could

have an adverse effect are not controlled locally.

2) Projects can substitute for existing imports. In

development economics terms, such projects are undertaken

for the purpose of "import substitution." If such

projects can produce and sell at the same price or lower

than the price of the imported item, the project enters

an already developed market. This implies that the

degree of risk which indirectly measures the probability

of failure will be very low provided that management is

efficient, the product is good, and other factors which

can adversely affect the project are controlled.

3) Projects can produce items which can be directly

utilized in the economy. If these are new products, a

very intensive program of market development has to be

undertaken. There is considerable risk in this.

Introducing a new product into the market is not the

simplest activity.

Such analysis coupled with empirical study would result in quanti-
fication of the risk associated with each type of project.

For the purpose of the deterministic case, which this study is

about, the social rate of discount is a function of the source of fund

and is always given by the following relationship

$$I_c = I_s$$

where

I_c = cost of capital, and

I_s = social rate of discount.

It can also be argued that at the early stage of economic development, the use of a higher social rate of discount than the cost of capital might have a retarding effect on economic development. The economy needs all the help it can get to make it self-sustaining.

CHAPTER VI

A NUMERICAL EXAMPLE

The government of Neptune has budgeted $100,000,000 for develop-
ment purposes in the 1976 budget year. The Central Economic and
Planning Board (CEPB) of Neptune has agreed to spend the $100,000,000
on worthwhile projects. The Board has decided that economic develop-
ment can best be achieved through the process of public fund investment
in projects. The CEPB has passed directives to all the development
oriented agencies of the government to study and present development
projects. The Planning Programming Unit (PPU) of each agency in
cooperation with the Project Coordination section of the Ministry of
Planning and Economic Development (MPED) is responsible for project
development.

Background Information

Neptune is a small island in the Pacific with a population of
about 12 million. It is predominantly an agricultural nation. The
method of agriculture is still primitive, but the land is fertile.
Most of the people live on small farms which are basically unproductive.
The capital city, Mars, is the only urbanized city. It is located in
the eastern region of the country. The eastern region is relatively
more developed than the rest of the regions.

The government of Neptune in its annual budget message has outlined the objective of the government as follows:

1) Maximize national income.

2) Maximize employment.

3) Maximize the foreign exchange earnings.

4) An equitable distribution of income among all regions.

The CEPB with the assistance of the experts of the MPED has divided the country into three economic regions: 1) the eastern region, 2) the north-central region, and 3) the southwestern region. The eastern region is relatively industrialized and the economic activity is progressive. The north-central region is the most fertile region and agricultural development is being instituted. The south-western region is the most backward part of the country.

The CEPB with the help of the experts of the Project Coordination division of the MPED has gone through the exercise of assigning economic weights as discussed in Chapter IV. The results are tabulated in Tables VI and VII.

TABLE VI

NEPTUNE'S DEVELOPMENT OBJECTIVES

Macroeconomic Objectives	Economic Weights
National Income	0.75
Employment	0.20
Balance of Payment	0.05

TABLE VII

NEPTUNE'S ECONOMIC REGIONS

Economic Regions	Economic Weights
Eastern Region - R_1	0.08
North-Central Region - R_2	0.30
Southwestern Region - R_3	0.62

Neptune has valuable mineral resources, and its export of these items is stable. The balance of payment of Neptune is very favorable as it stands now. Hence the CEPB has assigned an economic weight of 0.05. The main thrust according to the board is to increase national income so that capital will be available in years to come. This would enable the economy to be self-sustaining. The employment objective is assigned a factor of 0.2.

The different economic regions are also weighted, as shown in the table. In the analysis of the example projects in this section, the cost of locating any one of the projects in region I, II, or III is variable. For simplicity, it is assumed here that the NPSV of a project in region II is 80% of the NPSV in region I, and that of region III is 70% that of region I. The difference in the net present social value is due to the added expense of locating a project in a place where services are hard to get. Transportation, managerial service, availability of goods and other supporting services are more expensive in the underdeveloped regions of the country.

According to the procedure of public project analysis, each PPU of the government agencies must develop projects within its specific area. Consistent with this approach, the PPU's of the Ministry of Agriculture and the Ministry of Commerce and Industry have presented two projects each.

Proposed Projects

Agriculture Department

Two projects are proposed by the Agriculture Ministry. The first project proposed is a fertilizer industry. It is hoped that this will have a positive impact on the agriculture of the country. Up to this point the country has been importing fertilizer in the amount of $4.5 million dollars. The development of this project would free this foreign exchange, since its proudct would satisfy the nation's demand. The second project is a semi-mechanized public owned farm. It is predicted that this will increase agricultural output considerably. The project parameters are given below:

	Project A Fertilizer Industry	Project B Semi-Mechanized Farm
Initial Investment	$4,500,000	$37,000,000
Operating Cost	$4,300,000/yr	$ 3,000,000/yr
Project Revenue	$7,500,000/yr	$ 7,000,000/yr
Semi-skilled Workers	950	500
Unskilled Workers	2000	1500
Foreign Exchange Earned	$4,500,000/yr	$ 1,500,000/yr
Foreign Exchange Spent	$ 500,000/yr	$ 1,500,000/yr
Life of the Project	30 yrs	30 yrs

Industry and Commerce Department

This ministry proposes two projects--the only projects found acceptable after preliminary evaluation. These are a meat processing industry and a textile industry. The meat processing industry is mainly for export, and it is expected to generate some foreign exchange. The textile industry is for local use, but it will substitute for imports which make up a substantial portion of the foreign exchange expense. The project parameters are given below:

	Project C Meat Canning Industry	Project D Textile Industry
Initial Investment	$56,000,000	$63,000,000
Operating Expense	$ 6,300,000/yr	$10,300,000/yr
Project Revenues	$10,800,000/yr	$15,300,000/yr
Semi-skilled Workers	1,000	3,000
Unskilled Workers	3,500	4,000
Foreign Exchange Earned/Saved	$ 2,000,000/yr	$ 5,300,000/yr
Foreign Exchange Spent	$ 1,000,000/yr	$ 1,300,000/yr
Life of the Projects	30 yrs	30 yrs

The government has obtained a development budget of $100,000,000 from the International Bank of Reconstruction and Development (IBRD) at an interest rate of 4%. This rate determines the cost of capital which determines the social rate of discount.

$$I_c = 4\% = I_s$$

The minimum annual wage of a semi-skilled worker is $2000, and that of an unskilled worker is $1000. These projects are analyzed using two social discount rates.

1) $I_s = I_c = 4\%$.

2) $I_s = I_c + \text{risk factor} = 4 + 2 = 6\%$

(a risk factor of 2% is arbitrary).

Traditional Project Evaluation (Profitability)

For project j, the NPSV is given by:

$$NPSV_j = \sum_{N=0}^{t} [(B_{j_t} - C_{j_t})\beta^{-t} - K_{j_t}\beta^{-t}]$$

$$\beta = (1 + i_s)$$

Project A

$$NPSV_A(4\%) = \sum_{N=0}^{30} [(7.5-4.3)(1+.04)^{-t} - 45(1+.04)^0]$$

$$= \$10.3344 \text{ (all figures are in millions of dollars)}$$

$$NPSV_A(6\%) = \sum_{N=0}^{30} [(7.5-4.3)(1+.06)^{-t} - 45(1+.06)^0]$$

$$= -\$0.95264$$

Similarly:

$$NPSV_B(4\%) = \$32.168$$

$$NPSV_B(6\%) = \$18.0592$$

$$NPSV_C(4\%) = \$21.814$$

$$NPSV_C(6\%) = \$5.9416$$

$$NPSV_D(4\%) = \$23.46$$

$$NPSV_D(6\%) = \$5.824$$

Ranking According to NPSV

Project	At 4%	At 6%
A	4	unacceptable
B	1	1
C	3	2
D	2	3

According to the net present social value, project B (the semi-mechanized farm) is the best, and the textile industry is second best. These two projects would be selected. The question is how reliable is this selection process. This approach, based on a single objective, gives only a partial view of the problem. Multiple objectives with the proper tradeoff values must be used.

The Multiple Objective Model

This model maximizes a collection of national macroeconomic objectives. The objective function is

$$\sum_{r=1}^{Q} I_r \sum_{j=1}^{M} \left[W_i \sum_{t=0}^{N} \left\{ (B_{j_t} - C_{j_t}) \beta^{-t} - K_{j_t} \beta^{-t} \right\} + W_2 \sum_{t=0}^{N} (\gamma_1 L_{1j} + \gamma_2 L_{2j}) \beta^{-t} \right.$$

$$\left. + W_3 \sum_{t=0}^{N} (F_{s_j} + F_{e_j} - F_{o_j}) \beta^{-t} \right] X_{jr}$$

For the example problem let

X_{11} be project A in Region I

X_{12} be project A in Region II

.
.
.

X_{23} be project B in Region III

The example problem is formulated as shown here.

$$\text{Maximize} \sum_{r=1}^{3} I_r \sum_{j=1}^{4} \left[.75 \sum_{t=0}^{30} \left\{ (B_{j_t} - C_{j_t})\beta^{-t} - K_{j_t}\beta^{-t} \right\} \right.$$

$$+ .2 \sum_{t=0}^{30} (2000\ L_{1j} + 1000\ L_{2j})\beta^{-t}$$

$$\left. + .05 \sum_{t=0}^{30} (F_{s_j} + F_{e_j} - F_{o_j})\beta^{-t} \right] X_{j_r}$$

Subject to

$$K_j X_{jr} \leq 100,000,000 \qquad - \quad \text{Budget}$$

$$X_{11} + X_{12} + X_{13} \leq 1$$

$$X_{21} + X_{22} + X_{23} \leq 1 \qquad \text{Mutually exclusive projects}$$

$$X_{31} + X_{32} + X_{33} \leq 1$$

$$X_{41} + X_{42} + X_{43} \leq 1$$

Calculation of the coefficients

$$\sum_{t=0}^{30} \left\{ (B_{j_t} - C_{j_t})\beta^{-t} - K_{j_t}\beta^{-t} \right\} = NPSV_j$$

$$\sum_{t=0}^{30} (2000\ L_{1j} + 1000\ L_{2j})\beta^{-t} = PTRI_j$$

$$\sum_{t=0}^{30} (F_{s_j} + F_{e_j} - F_{o_j})\beta^{-t} = PFEEP_j$$

	X_1	X_2	X_3	X_4
NPSV (4%)	10.3344	32.168	21.814	23.46
(6%)	- 0.95264	18.0592	5.9416	5.824
PTRI (4%)	67.4388	43.23	95.106	172.92
(6%)	53.68272	34.412	75.7064	137.648
PFEEP (4%)	69.168	0	17.292	69.168
(6%)	55.0592	0	13.7648	55.0592

Using a social rate of discount of 4%, the objective function becomes:

$$.08[(.75)(10.334)+(.2)(67.4388)+(.05)(69.168)]X_{11}+0.3[(.8)(.75)(10.334)$$
$$+ (.2)(67.4388)+(.05)(69.168)]X_{12}+.62[(.7)(.75)(10.334)+(.2)(67.4388)$$
$$+ (.05)(69.168)]X_{13}+.08[(.75)(32.168)+(.2)(43.23)+(.05)(0)]X_{21}$$
$$+ 0.3[(.8)(.75)(32.168)+(.2)(43.23)+(.05)(0)]X_{22}$$
$$+.62[(.7)(.75)(32.168)+(.2)(43.23)+(.05)(0)]X_{23}+.08[(.75)(21.814)$$
$$+ (.2)(95.106)+(.05)(172.92)]X_{31}+.03[(.8)(.75)(21.814)+(.2)(95.106)$$
$$+ (.05)(172.92)]X_{32}+.62[(.7)(.75)(21.814)+(2)(95.106)$$
$$+ (.05)(172.92)]X_{33}+.08[(.75)(23.46)+(.2)(172.92)+(.05)(69.168)]X_{41}$$
$$+ .3[(.8)(.75)(23.46)+(.2)(172.92)+(.05)(69.168)]X_{42}$$
$$+ .62[(.7)(.75)(23.46)+(.2)(172.92)+(.05)(69.168)]X_{43}$$

This can be simplified into:

$$1.98\ X_{11} + 6.95\ X_{12} + 13.87\ X_{13} + 2.62\ X_{21} + 8.39\ X_{22} + 15.84\ X_{23}$$
$$+ 3.52\ X_{31} + 12.23\ X_{32} + 24.26\ X_{33} + 4.45\ X_{41} + 15.64\ X_{42}$$
$$+ 31.22\ X_{43}$$

The problem can be formulated as:

$$\text{Max } 1.98\ X_{11} + 6.95\ X_{12} + 13.87\ X_{13} + 2.62\ X_{21} + 8.39\ X_{22} + 15.84\ X_{23}$$
$$+ 3.52\ X_{31} + 12.23\ X_{32} + 24.26\ X_{33} + 4.45\ X_{41}$$
$$+ 15.64\ X_{42} + 31.22\ X_{43}$$

Subject to:

$$45(X_{11} + X_{12} + X_{13}) + 37(X_{21} + X_{22} + X_{23}) + 56(X_{31} + X_{32} + X_{33})$$
$$+ 63(X_{41} + X_{42} + X_{43}) \leq 100$$

$$X_{11} + X_{12} + X_{13} \leq 1$$

$$X_{21} + X_{22} + X_{23} \leq 1$$

$$X_{31} + X_{32} + X_{33} \leq 1$$

$$X_{41} + X_{42} + X_{43} \leq 1$$

The solution becomes:

$$X_{43} = 1$$

$$X_{23} = 1$$

All the rest $X_{j,r} = 0$

The projects selected are project 2 and 3 at an investment of

$100,000,000 and their present worth contribution to the economy is

$47,060,000.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

The central thesis of this study is that single objectives do not
measure the true value of a project to a nation's economy. The
objectives have to be given out as a policy by the government, and all
project analyses must be based on these objectives.

In Chapters II and III the basic economic considerations were
outlined and a systems approach to analytical thinking was presented.
A summary of what governments of many developing nations consider to
be their major economic objectives was given. In almost all instances
the study showed that each government had multiple objectives in its
development plan. But the plan with its proper set of objectives was
rarely employed. The many developing nations who invested huge sums of
public funds in the last two decades are still in the same position on
the development scale. This fact attests that proper implementation of
public policy was not followed.

In Chapter IV a method of weighting objectives using a successive
comparison approach was suggested. This method uses a group of people
who, because of their responsibility and the positions they hold, are
believed to be knowledgeable about the economic development of the
nation. The successive comparison approach assumes that members of
this panel are equipped with the necessary educational and practical
expertise. This panel, which was referred to as the Central *Economic*

and Planning Board (CEPB), sets the objectives, the priorities among objectives, the priorities among regions in development, and is responsible for the approval of projects.

In Chapter V, an aggregate model for project evaluation was formulated. The model takes into consideration the tradeoffs between objectives and attempts to maximize the collective satisfaction of the aggregate macroeconomic objectives. The objectives used in this thesis are not necessarily what the developing nations have to institute. These are the most commonly used, and each nation should present itself as a unique case in assessing what the development objectives should be.

In the hypothetical numerical example presented in Chapter VI, it is shown that the ranking of projects based on a single profitability objective is different from that obtained using the multiple macro-economic objectives model. The ranking using the two methods is given here.

Projects	NPSV(4%)	Rank	Project Value	Rank
I	10,334,400	4	13,870,000 (reg.3)	4
II	32,168,000	1	15,840,000 (reg.3)	3
III	21,814,000	3	24,260,000 (reg.3)	2
IV	23,460,000	2	31,220,000 (reg.3)	1

As can be seen, the rankings of the two models are different. The multiple objectives model reflects the government's priorities among the different development objectives.

Recommendations

The discussion of public project selection is based on the concept of central planning. The experience of the eastern European nations

and the Soviet Union must be reviewed before any attempt is made to implement the model. A considerable amount of literature has been written on the experience of these nations. Appropriate references are given in the bibliography.

The concept of goal programming is useful in public decisions involving multiple objectives. Recent literatures have indicated the applicability of goal programming in the private sector. More theoretical research and empirical analysis is needed to determine the application of goal programming in public decision making.

The importance of economic data in project analysis cannot be overemphasized. Economic policies must be based on actual data. Planning will lose its meaning if it is not based on sound economic information. The lack of such information is one of the basic problems of developing nations. Basic research is needed to develop a comprehensive and adoptable data processing technique for the developing nations.

The process of public project selection using multiple objectives requires quantification of priorities among the objectives. The basic assumption in the assignment of quantitative values to the objectives is that the priorities reflect society's valuation. This process could be improved if basic economic information is readily available. The recording of economic information systematically can result in an updated file which can be used by planners and researchers. The need for more empirical study in priority setting cannot be overemphasized.

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        George Allen and Unwin Ltd., 1973.

VITA γ

Tesfaye Aklilu

Candidate for the Degree of

Doctor of Philosophy

Thesis: PROJECT SELECTION WITH MULTIPLE MACROECONOMIC OBJECTIVES: AN ECONOMIC EVALUATION MODEL FOR THE DEVELOPING NATIONS

Major Field: Industrial Engineering and Management

Biographical:

Personal Data: Born in Addis Abeda, Ethiopia, November 10, 1944, the son of Mr. and Mrs. Aklilu Dadi.

Education: Graduated from Tafari Makonnen High School, Addis Abeba, Ethiopia, in May, 1963; received the Bachelor of Science degree in Mechanical Engineering from Oklahoma State University in 1969; received the Master of Science degree in Industrial Engineering and Management from Oklahoma State University in 1970; completed the requirements for the Doctor of Philosophy degree at Oklahoma State University in May, 1975.

Professional Experience: Consultant/Trainer in Industrial Engineering with the International Labor Organization project in Ethiopia, 1970-71; National Expert, Industrial Engineering in the same project, 1971-72; teaching assistant, Department of Industrial Engineering and Management, Oklahoma State University, 1972-73; part-time instructor, Oklahoma State University, 1973-1975.