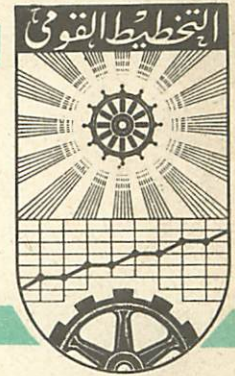# ARAB REPUBLIC OF EGYPT

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Investment Planning

A Proposed Goal Programming Approach

By

Dr. Saadia H. Montasser

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I. Why Goal Programming

Investment evaluation is characterized by multiple
objectives. This is true at the national level as much as at
the sectoral or project level. The problem usually encounter-
ed is how to incorporate those multiple, often conflicting,
goals in the process of evaluation.

Several approaches to investment evaluation have pro-
posed to consolidate the multiple objectives into a single
aggregate criterion for evaluation. They did so by introducing
the concept of a numéraire. One of the objectives, usually the
one considered the most important, is chosen as a numéraire, and
is assigned a weight of unity. Other objectives would be ex-
pressed in terms of this numéraire. The choice of the numéraire
differs from one approach to another. The UNIDO Guidelines (2),
suggests aggregate consumption as the numéraire. The rationale
given is that since welfare is the ultimate goal of development,
welfare could best be measured by the increase in the net present
aggregate consumption. Thus, the impact of an investment project
on welfare could be measured in terms of its addition to aggregate

consumption. Aggregate consumption is defined as the net output which is "the goods and services made available to the economy that would not have been available in the absence of the project" (2, PP. 40-41). This net output is valued at the consumers, "willingness to pay" and is discounted to the present. The discounting is carriedout using a social rate of discount which reflects the decline rate of the value of future consumption in relation to present consumption.

Other objectives are expressed in terms of this unit consumption, i.e. assigned a weight or a shadow price. Therefore, the part of net output directed to investment is considered as indirect consumption benefits and is valued at the shadow price of investment and added to direct consumption benefits to obtain the aggregate consumption benefits of a project. (1, P.3).

The shadow price of investment is the present value of the additional consumption that a unit of investment would generate (2, P.150). In a similar manner, the employment objective would be considered through the shadow price of labor (skilled and unskilled), and the balance of payement objective would be considered through the shadow price of foreign exchange.

The evaluation process would then proceed using these shadow prices instead of market prices to evaluate output, inputs and net output of a particular investment project. Adding up the net aggregate consumption benefits using these prices would provide the evaluator, hence the decision maker with a single criterion for evaluation.

The OECD approach (8 and 9), on the other hand, takes as a numéraire "the net present investment benefits in the hands of the government measured in foreign exchange, converted into domestic currency at the official exchange rate and discounted to present value (3, P.4).

Therefore, both investment and consumption streams resulting from an investment project, in any given time period, are all converted in terms of the numéraire, a unit of investment, and summed up. Our concern here is to find the value of consumption in terms of investment i.e. the cost of consumption with regard to the regard to the related loss in available investment funds (3., P.14).

Both the UNIDO and OECD approaches need, in order to compose the aggregate criterion, to assign numerical weights to different aspects of development in terms of the chosen numéraire. Those weights should reflect in part the political value judgement based on prevailing

conditions, social objectives and available resources. Therefore, these weights will produce what could be called national parameters which will be true only for those particular conditions, objectives, and resources. As soon as they change, which will happen as a result of the implementation of the investment plan, the weights should be changed accordingly. This complicated task would require abundant data and highly qualified personnel. Thus, the attempt to assign weights-as precise as the figures may be-is an ambitions and responsible exercise which is the expression of political value judgements in numerical terms and should be carried out by highly competent and well informed people. Even the most competent top policy makers, as a rule, in practice refrain from being too explicit in formulating national objectives and particularly in assigning numerical weights to those objectives. It could not, therefore, be expected to be valid for the developing countries (14, P.22).

If the aggregate criterion is, on practical grounds, rejected as a basis for investment evaluation, what could be considered as a viable and practical alternative?

The author of this paper advocates the use of the UNIDO-IDCAS Manual approach (14). In addition to personal bias, being one of its

authors, it is my belief that this manual does overcome some of the problems encountered in applying the above mentioned approaches. In addition, the UNIDO-IDCAS, Manual was designed to fit the conditions, stage of development, and information availability in the Arab coun-tries.

The UNIDO-IDCAS Manual recommends the use of a set of criteria for assessing the contribution of an investment project on the achievement of the different national development objectives.

1) Value added is adopted as a proxy measure for national welfare which is the ultimate goal of any development or investment plan. The contribution of an investment project in the making of national income could be measured by its net value added.

2) The number of jobs created by the investment project is a measure of its employment effect. This could be further classified into skilled and unskilled labor, Also, the sum of direct and indirect employment would make the total employment effect of a project.

3) The distribution of the generated value added among different income groups or among different regions has been a matter of

increasing concern in evaluating development programs. This could be measured by the ratio to the total value added of the value added going to the specific income group or the particular region.

4) The effect of an investment project on the country's foreign exchange position would be particularly of importance if the given country has a foreign-exchange problem. According to the data available, the net foreign exchange effect could be assessed through finding the balance of payment effect of a project, or the import substitution effect of a project.

5) If the project being evaluated is export oriented, it would be important to measure its international competitiveness to make sure that its products are exportable. This is achieved through the comparison of the inputs of domestic resources for the production of the exported items with the benefits that would be received from exports.

For the simulaneous consideration of these multiple objectives in the evaluation of investment projects, the UNIDO-IDCAS Manual proposes to consider one of these objectives as the basic criterion and others as additional indices.

The distinction between which is the basic criterion and which are the additional indices is left optional to be decided upon in line with national objectives and prevailing conditions.

The purpose of this study is to propose an alternative approach to accomodate the multiple objectives for evaluation without the need to combine them in one complex criterion. Goal programming is an operations research technique especially designed to deal with multiple, sometimes conflicting objectives (4, P.1). In contrast to linear programming which considers only a single objective, goal programming is a multiple objective, decision model. Moreover, goal programming is more flexible than linear programming in that it does not fail to yield a feasible solution in cases when the constraints are not absolutely binding which often occurs. In such cases, linear programming renders the solution as infeasible. Since goal programming deals with multiple objectives, priorities will have to be assigned to each objective or set of objectives.

II. Objectives and Priorities of the Proposed Model.

In using goal programming the evaluator recognizes that:

(a) There are more than one objective (b) Not all objectives can be optimized

but the goal programming scheme allows us to go as close as possible to the satisfaction of these objectives (c) There is no distinction between objectives and constraints except that what are considered as absolutely binding constraints should be given higher (First) priority as objectives so that they are completely satisfied (if at all possible). While nonabsolute constraints will be treated as lower priority objectives.

Goal programming will work for minimizing the deviation of these lower order objectives from their prespecified level without jeopardizing the achievement of the higher priority objectives. Therefore, goal programming seeks the satisfaction of objectives in their priority order, meaning that higher priority objectives could be achieved at the expense of lower priority ones but not the other way around.

In applying the goal programming approach to investment planning here, we shall assume that the social objectives and priorities had already been used in allocating total national investments among various sectors. We stand now in the second or third phase of planning concerned with distributing the investment (local and foreign) allocated to some industrial sector among its component subsectors which are: .
(a) Food industries, (b) beverages, and (c) tobacco.

The objectives of the goal programming are channeled down from the national objectives indicated in the five year plan 1981-82-1986/87. On the subsectors level, they are considered as follows?

First: The total amount of investment to be allocated is £ 265 million in local currency and £ 236 in foreign currency. Let us use x_1, x_2, and x_3 to indicat the decision variables reflecting the amount, in million, of output in the three subsectors of food industries, beverages, and tobacco respectively. The local investment objective could be expressed in the equation:

$$.201 \ x_1 + .087x_2 + .257x_3 + n_1 - P_1 = 265 \qquad (1)$$

The x's coefficients reflect local investment output ratio in the three subsectors respectively. n_1 and P_1 indicate negative and positive deviations from the target. Likewise, the foreign investment objective could be expressed in the form:

$$.188x_1 + .086x_2 + .185x_3 + n_2 - P_2 = 236 \qquad (2)$$

The x's coefficients in equation (2) represent foreign in-
vestment / output ratios for the three subsectors. n_2 and p_2 in-
dicate negative and positive deviations from the foreign investment
target. Since equations (1) and (2) reflect resources limitation,
they represent absolute objectives that have to be met and thus must
be assigned top priority level.

Second: Demand estimates for the purpose of new investment
evaluation is usually more difficult than for going concerns and it
covers much longer span of time (12, P.1). It is believed that within
the span of the current five year plan, and within the investment
limitations, all expected output will be highly demanded in the
domestic market. This is an indication that no upper limits on output
need to be inforced.

Third: The current plan indicates a priority given to replace-
ment and renovation investment. Since a break down of relevant data
between new projects and replacement projects was not available, it is
suggested that after allocation of investment among subsectors is made,
priority within each subsector could be given to replacement projects.

Fourth: The contribution of this industrial sector to the na-
tional welfare is measured by the generated value added. This is

assigned second priority level. In goal programming absolute maximization of an objective is not allowable (4, P.14). This objective is assigned "a reasonable" lower bound to be achieved or nearly achieved via the investment plan. Instead of optimizing an objective, the purpose in goal programming is to minimize the deviations from the prespecified objective. Within the above limitations on local and foreign investment and considering the value added/investment ratio in each subsector, we believe that a value of $£$ 350 million is a reasoneble lower bound on value added. Using the estimated value added output ratios, the value added function is:

$$.15x_1 + .36x_2 + .11x_3 + n_3 - p_3 = 350 \qquad (3)$$

Fifth: Impact on employment is an important aspect of investment planning especially when unemployment or underemployment charactrizes the economy. Employment is desired as an objective in itself and for its effects on other objectives of development such as value added and income redistribution (new employment opportunities channel new incomes to the poorer segments of the society, therefore contributes to income redistribution target (11, P.5) However, higher employment might have an adverse effect on investment since most wage income would be spent on consumption (11, P.6).

Employment objective will be measured by the number of created jobs, per unit of output. Within the limitations of the given investments and considering the output/labor ratio in the given subsectors, a targeted lower bound on the employment objective is set at 90000. Using the number of job opportunities per million pounds of output, the employment objective is expressed in the form:

$$76x_1 + 26x_2 + 18x_3 + n_4 - P_4 = 90000 \qquad (4)$$

Sixth: The generation of income reflects the effeciency aspect in investment planning. The aspect of equity will have to be examined through the evaluation of the distribution of the generated income. Here, the wage income is used as a measure of income going to the poorer segment of the society and is used as a measure of how equitible the distribution is. A lower bound of £ 210 million(60% of the targeted lower bound on value added) is set on this objective. Equation (5) expresses this objective:

$$.10x_1 + .15x_2 + .04x_3 + n_5 - p_5 = 210 \qquad (5)$$

Seventh: Though important, no information in the required details, was available about the suggested investments effects on the

balance of payment. Therefore, this aspect was not considered in the model. According to the previous discussion, the first priority level $(p_r)1$ is assigned to the investment objective functions (1) and (2). Since these objectives are not to be exceeded, the objective will be to minimize the positive deviations p_1 and p_2. Priority levels $(p_r)2$, $(p_r)3$, and $(p_r)4$ are assigned to functions (3),(4) and (5) respectively. They are all given equal weights. Since, the objectives of these functions represent lower bounds, the deviation variables to be minimized are n_3, n_4, and n_5. The resulting achievement function is in the form:

$$\text{minimize} \quad \left[\quad (p_1 + p_2) \, , \, n_3, \, n_4, \, n_5 \quad \right] \qquad (6)$$

Subject to the preceding objective functions (1) to (5).

III. Implementation of the Model.

We next proceed to find the "best" investment plan, in terms of achieving the prespecified multiple objectives. It is more convenient to use the condensed tableau of linear goal programming in which the identity matrix is eliminated, To start with the initial tableau, define its elements as follows (4, PP.40-44). Headings:

$(p_r)k$ = the kth priority level.