

# Some Recent Applications of Programming in Planning and Economic Development

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## Summary

0-1. This paper attempts at giving some recent developments in the line of programming techniques that are applied in planning and economic development. Mostly, some interesting applications in Indian planning and in the American economy have been mentioned. The Operational Research approach in Indian planning is due to Prof. P. C. Mahalanobis, which has been later developed by many other planners, economists and statisticians. Mention is made of some recent models for long term planning in India. Next, an application of Linear Programming in regional planning has been briefly given.

The latter part deals with an interesting application of Linear Programming models in Process Analysis used in industrial and economic development. In the end, applications of programming techniques in input-output models and in pricing policy models have been mentioned. Lastly, the present situation and attempts for the development of Operations Research in some of the organisations have been given.

## INTRODUCTION

1-1. Operations Research emerged out in connection with military operations and after the World War II. O. R., has been applied in industrial, governmental, commercial and other activities. Churchman,

Ackoff and Arnoff [1] discussed O. R. techniques under certain classes depending on the type of process, like Inventory process, Allocation process, Waiting time process, Replacement process, competitive process and other combined processes.

1.2. Now-a-days attention is being paid on the rigorous theoretical development of the subject and besides other problems, the allocation and programming problems are being concentrated upon, which deal with the allocation of 'men, materials or machines'. The objective here is to determine the most efficient types of allocation of resources (limited or incapable of complete utilization), so that a measure of performance is optimized. Sasieni, Dean and Shiv K. Gupta [2] define 'Linear Programming' as the one in which this measure is a linear function of the controllable variables and the restrictions or 'resource availability' are expressible as a system of linear equations or inequalities'. A lot of work has been done on this subject, on the mathematical as well as practical side of it, by Koopmans [3], Dorfman, Samuelson and Solow [4], Gas [5], Vajda [6], Dantzig [7], Arrow, Hurwicz and Uzawa [8], Kuhn and Tucker [9] and many others. Recent developments are on the linear programming side.

2.1. Programming techniques are of wide application in planning, because usually we are concerned with the maximization of certain 'welfare or profit functions' or minimization of 'loss or risk functions' subject to certain restrictions. Translation of these restrictions into mathematical language and forming the objective function mathematically, helps in the ready applicability of programming, under certain conditions. In Indian planning this approach has been initiated by Prof. P. C. Mahalanobis.

2.2. The basis of 2nd five year plan has been worked out using an allocation model developed by Prof. Mahalanobis [10]. The object of the model is to get a consistent solution to attain a desired rise in National Income as a result of given level of investment and at the same time creating a desired volume of employment'. The model is well-known as the 'Four sector model' which consisted of sector (a) producing investment goods, and three sectors producing consumer goods, viz., (i)

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factory production, (ii) agricultural and household industries and (iii) service sectors. The use of Linear Programming techniques, the actual background existing in the nation, the urgency to solve the problem have been discussed in a paper by Prof. Mahalanobis and Prof. Mukherjee [11].

3-1. Frish [12] and Sandee [13] developed models for Indian planning which use Linear Programming techniques. Maximization of a weighted function of income and employment is the criterion used in [12], where as in [13] maximization of consumption has been attempted.

3-2. One of the recent models is the one given by Rudra [14]. This is in relation to long-term planning having the following objectives :

- $O_1$  Per-capita consumption on essential consumer commodities to be not less than certain normative quantities,
- $O_2$  Availability of certain social services to the population at certain normative rates,
- $O_3$  Reduction of degree of inequality from the base year value to a lower one,
- $O_4$  The ratio of gross fixed capital formation to gross national income to be equal or greater than a given value,
- $O_5$  Equality of foreign exchange earnings and foreign exchange spendings.

The feasibility conditions are that

- $F_1$  Supply is greater than demand, resulting in addition of stocks,
- $F_2$  Receipts in every activity sector equal disbursement.

The criterion of efficiency that has been chosen for the plan is minimization of foreign assistance. In order to get at the solution, programming techniques coupled with 'iterative processes' have been used in [14].

4-1. The Linear Programming is used in analysing the important inter-relationships among productive sectors of the economy. Using a

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inter-regional Linear Programming model, one can visualise an optimum multi-regional economy in which ways and means as well as levels of production in each region can be shifted, by a reallocation of resources, resulting in efficient patterns. Models have been developed by Stevens [15] and Isard [16] and many others. In [15] Stevens maximized the GNP (sum of regional products) subject to the restrictions that (i) the utilization of resource by industries in a region cannot exceed the endowment of resource in that region, (ii) the industrial requirement of investment goods in a region will be used up by industrial consumption there and (iii) level of consumption of final goods in a region must be at least large enough to supply the minimum consumption in that region.

4.2. In regional planning models, minimization of transport costs, processing and production costs, maximization of growth rates, incomes or employment, minimization of labour inputs etc., are some of the other objective functions, usually considered.

5.1. Linear Programming is also being applied in Process Analysis, 'to study the production capabilities of industries and complexes. Manne [17] used Linear Programming in the formulation of a model for the U.S. Petroleum refining industry. Heady and Egbert [18] used spatial programming models in order to get at the pattern of grain production over regions for U.S. agriculture. Fabian [19] used a linear programming model for Integrated Iron and Steel Production. Machine tools substitution analysis and metal working requirement analysis also are based on programming and transportation (allocation) techniques.

5.2. Manne [20] made a Linear Programming analysis of the economic development of the Mexican Economy, over the time horizon of ten years 1960-70. He minimized the inflow rate of foreign loans and aid required by the key sectors, subject to the final demand restrictions, resource availability and non-negativity restrictions.

5.3. Sectoral development plans can be drawn using techniques of process analysis models. Thomas Vitorisz [21] studied this problem which involves in the determination of the existing conditions within the sector, with their background and their connectedness with the rest of

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the economy. When the planning commission (central organisation) is the nucleus and the inter-relations between the various units are very important, then these units are to be well co-ordinated and balanced. These inter-relations can be analysed by individual sectoral programme analysis models and models for the whole economy, and find the inter-relations betwixt them. Here comes the application of the decomposition method of solving Linear Programming problem, given by Dantzig and Wolfe [22]. In [21], we find how it can be applied and a complete discussion is given therein.

6.1. In the input-output models, Linear Programming techniques are used in determining the technological choice or in establishing the inter-dependence between regions, with an allocation of resources in such a way as to minimize the total cost of production and transportation. Chenery and Clark [23] give some industrial applications of programming. In the determination of pricing policies also programming is applicable. For example, in the case of coal industry, given the demands, the cost of extraction for each coal block, and the cost of transportation are minimized by programming and allocation techniques. Henderson [24] gives a full discussion of the coal industry.

7.1. Now-a-days the subject is being developed and there is considerable expansion on the knowledge of computations. Electronic Data Processing Machines and other Computers can now solve, even problems of large size, very quickly.

7.2. In India, Operations Research as well as Mechanical data Processing are of recent origin. The Indian Statistical Institute and the Indian Institute of Management, tackled many problems, besides the training given in Operations Research and Management Science. The University of Delhi also has started a two year post-graduate course in O.R. The Research and Development Organisation, Ministry of Defence is highly responsible for research work in O.R. There are O.R. groups in certain well-known industrial establishments. Coupled with the techniques of Statistical Quality Control, these can expand the industrial activities to a large extent. Thus, in course of time, as the subject O.R. gets developed, it would be quite easy to solve the most intricate problems of planning quickly.

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