Relevance of Operations Research Techniques in the Regime of Globalization — A Case Study

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Abstract

Growing complexities in Indian organizations under the umbrella of globalization have led to the development of new tools, techniques and systems of management to facilitate decision-making processes and management functions. Operations Research techniques is one of the powerful tools in the hands of modern management. Enlightened managers need appropriate information of quality in adequate quantum as well as on time for effective and efficient decision-making. Development of suitable operations research techniques is thus one of the primary tasks before the Indian managers today.

A very few Indian organizations as of today have operations research techniques which meet their specific role of providing the required information to the managers for facilitating the processes of decision-making. It is, therefore, of paramount importance that a systematic and detailed study of management functions, decisions, and information needs be carried out in various types of Indian organizations with a particular socioeconomic and industrial environment. With the above backdrop, the present study has been conducted in the manufacturing industrial unit. This field study helped us in obtaining first hand information regarding the present systems practices in governance of such organizations. The present study has developed an operations research technique, for example, in Linear Programming model for optimum deployment of human resources in structural fabrication shops and has shown better productivity with lesser number of manpower with a factor of safety to meet unseen contingencies. The study has also given the birth of the concept of development of multi-skill workmen with additional incentives without going for retrenchment to survive in the arena of cut-throat competition in the present day scenario.

Key-Words : Operations Research ; Optimization ; Mathematical Programming ; Stochastic Process Techniques ; Design Variables.

Introduction

The term, Operations Research (O.R.), was first introduced in 1940 by McClosky and Trefthen in a small town, Bowdsey, of the United Kingdom. This new science came into existence in military context during World War II to evolve and suggest ways and means to improve the execution of various military projects. Following the end of the war, the success of military teams attracted the attention of industrial managers who were seeking solutions to their complex executive-type problems.

In India, Operations research came into existence in 1949 with the opening of O.R. unit at the Regional Research Laboratory, Hyderabad. At the same time, another group was set up in the

Defence Science Laboratory, Hyderabad. At the same time, another group was set up in the Defence Science Laboratory, which devoted itself to the problems of stores, purchase, and planning. In 1953, an O.R. unit was established in Indian Statistical Institute, Calcutta for the application of O.R. method in the national planning and survey. O.R. Society of India was formed in 1955 with the objective of producing well trained O.R. practitioners who can tackle practical problems. The Indian Institute of Industrial Engineers has also promoted the development of O.R. through its journals 'Industrial Engineering' and 'Management'. Other journals which deal with O.R. are : Journal of the National Productivity Council, Material Management Journal of India, and the Defence Science Journal.

Towards the applications of O.R. in India, Prof. P.K. Mahalanbis had make a break through for the formulation of the 2^{nd} Five year plan to forecast the trends of demand, availability of resources and for scheduling the complex schemes necessary for developing our country's economy.

In the industrial sector, it is unfortunate that only a very few organized industries in India are conscious about the role of O.R. But in the regime of globalization, to survive in the neck-to-neck competition, by dint of the increased productivity with quality bench mark the relevance of O.R. is becoming very important.

Meaning of O.R.

In fact, it is too difficult to define O.R. mainly because of the fact that its boundaries are not clearly marked. O.R. has been variously defined as the 'Science of use', 'Quantitative common sense', 'Scientific approach to decision-making problems' etc. O.R. is the art of giving bad answers to problems which otherwise have worse answers (Saaty, 1959). O.R. is a scientific method of providing executive departments with a quantitative basis for decisions under their control (Morse, P M & Kimball, G E). O.R. is the application of scientific methods, techniques and tools to problems involving the operations of a system so as to provide those in control of the system with optimum solutions to the problem (Churchman, Ackoff and Arnoff, 1957). O.R. is the applied decision theory. It uses any scientific, mathematical, or logical means to attempt to cope with the problems that confront the executive, when he tries to achieve a thorough-going rationality in dealing with his decision problems (Miller & Starr, 1973). An application of O.R. involves (Wagner, 1977).

1. constructing mathematical, economical, and statistical descriptions or models of decision and control problems to treat situations of complexity and uncertainty.

2. analyzing the relationships that determine the probable future consequences of decision choices, and devising appropriate measures of effectiveness in order to evaluate the relative merit of alternative actions.

Concept of Optimization

Optimization is the act of obtaining the best result under given circumstances. In manufacturing business, scheduling and sequencing the production runs by proper allocation of machines, calculating the optimum product mix, engineers or managers have to take many technical and managerial decisions at several stages. The main objective of all such decisions is to either minimize the effort required or maximize the desired benefit. Since the effort required or benefit desired in any practical situation can be expressed as a function of certain decision variables, optimization can be defined as the process of finding the conditions that give the maximum value of a function. The optimum seeking is also known as mathematical programming techniques which are concerned with the application of scientific methods and techniques to decision-making problems and with establishing the best or optimum solutions.

Methods of O.R.

- Mathematical programming techniques — These are useful in finding the minimum or maximum of a function of several variables under a prescribed set of constrained, e.g., calculus methods, calculus of variations, non-linear programming, geometric programming, quadratic programming, linear programming, dynamic programming, integer programming, stochastic programming, network methods : CPM, PERT, game theory.

- Stochastic process techniques — These can be used to analyze problems which are described by a set of random variables having known probability distribution, e.g., statistical decision theory, Marcov process, queuing theory, renewal theory, simulation methods, reliability theory.

- Statistical methods — These enable to analyze the experimental data and build empirical models to obtain the most accurate representation of the physical situation, e.g., regression analysis, cluster analysis, pattern recognition, design of experiments, discriminant analysis, factor analysis.

Classification of Optimization Problems

Optimization problems can be classified in several ways as described below :

- Classification based on the existence of constraints.
- Classification based on the nature of design variables.
- Classification based on the physical structure of the problem — it is, in turn, of two types : a) optimal control problem b) non-optimal control problem.
- Classification based on the nature of equations involved e.g, linear, non-linear, geometric, quadratic programming problems etc.

A case study

Objectives and Methodology of the present study

We are considering a manufacturing industrial unit of a public limited company of annual turnover 30000 million rupees and a profit of 250 million rupees, on an average for last two financial years with a total number of employees 400 only.

Specific objective of the present study was the optimum deployment of available resources for which production level should reach at its optimum point.

Phases of study

1. Critically study the present status of allocation of human resources in the different operational fields in the structural fabrication shops, for achieving the present production level.

Table 1

Nature of Present Human Resources Allocations

Names of the operational field	Operations code	No. of workmen	The available working time per man per day (minutes)	Available man-minutes per 25 days
Preparation/Marking	Op 1	60	390	585000
Gas Cutting	Op 2	45	390	438750
Shearing	Op 3	08	390	78000
Cropping	Op 4	04	390	39000
Saw	Op 5	05	390	48750
Rolling	Op 6	06	390	58500
Straightening	Op 7	10	390	97500
Drilling	Op 8	27	390	263250
Fitting	Op 9	60	390	585000
Grinding & Chipping	Op 10	30	390	292500
Riveting	Op 11	24	390	234000
Milling	Op 12	04	390	39000
Inspection	Op 13	30	390	292500

2. To Design appropriate methods of optimum deployment of human resources for the organization.

3. To frame out management policy to implement the optimum deployment of human resources for increased productivity in the backdrop of globalization scenario.

With the help of the Industrial Engineering Department, the standard time has been calculated for different operations against standard methods, technology, etc. for different products which is shown in Table No. 2.

Table 2

Product code	Wt. in tons	Op1 (man minutes)	Op2 (man minutes)	Op3 (man minutes)	Op4 (man minutes)	Op5 (man minutes)	Op6 (man minutes)	Op7 (man minutes)	Op8 (man minutes)	Op9 (man minutes)	Op10 (man minutes)	Op11 (man minutes)	Op12 (man minutes)	Op13 (man minutes)
P1	2.0	2786	2089	398	254	298	1160	1343	2786	1193	3603	398	1193	870
P2	1.7	2167	1625	310	0	232	903	1045	2167	1084	5171	309	1083	0
P3	1.9	3545	2659	506	0	380	1477	1710	3545	1773	7874	507	1773	0
P4	0.40	650	488	93	60	70	0	314	650	325	1860	93	325	203
P5	0.50	1115	836	160	101	120	464	537	1115	557	1638	0	557	0
P6	1.00	929	697	133	0	100	387	448	929	464	1626	0	464	0
P7	1.20	2167	1625	310	197	232	903	1045	2167	1084	2024	0	1083	877
P8	1.00	1393	1045	199	127	150	0	672	1393	697	2293	199	696	435
P9	0.29	1182	886	169	108	127	0	570	1182	591	1556	0	591	0
P10	0.15	260	195	38	24	28	0	126	260	130	491	0	130	0
P11	0.25	697	522	100	64	75	0	336	697	384	1755	0	348	0
P12	0.137	650	488	93	60	70	0	314	650	325	468	0	325	0
P13	0.051	650	488	93	60	70	0	314	650	325	351	93	325	0
P14	0.070	697	522	100	64	75	0	336	697	348	234	100	348	0

Mathematical formulation of the problem

The problem is how should the company allocate his 14 types of products so that the company may make the maximum production in a month. Here, the real situation is that the company can, if so chooses, produce few of the products and gives subcontract for the rest of the products for maximizing production within the given resources.

Let X1, X2, ..., X14 be the number of products of P1, P2, ..., P14 respectively that the company decides to produce per month. Then the monthly production is given by $Z = 2.0\,X1 + 1.7\,X2 + 1.9\,X3 + 0.4\,X4 + 0.5\,X5 + 1.0\,X6 + 1.2\,X7 + 1.8\,X8 + 0.29\,X9 + 0.15\,X10 + 0.25\,X11 + 0.137\,X12 + 0.051\,X13 + 0.07\,X14$

which is to be maximized, subject to

$$Op1 \leq 58500,\ Op2 \leq 438750,\ Op3 \leq 78000,\ Op4 \leq 39000,\ Op5 \leq 48750,$$
$$Op6 \leq 58500,\ Op7 \leq 97500,\ Op8 \leq 263250,\ Op9 \leq 585000,\ Op10 \leq 292500,$$
$$Op11 \leq 234000,\ Op12 \leq 39000,\ Op13 \leq 292500 \text{ and } Xj \geq 0\ (j = 1,2,........,14).$$

By making use of TEMPO mathematical programming package of Burroughs, where suitable re-allocation of slack resources can be done, we get the optimum allocation of human resources in different operations as shown in Table 3.

Discussion on results and findings of present study

1. It is observed that as per present allocation of human resources the production achieved is only 143.9 Metric tons and also there exists considerable idle resources in all the operations except one.
2. By suitable re-allocation of the slack resources we have been able to achieve a production of 343.38 Metric tons which is nearly 2.5 times of the present quantum of production.
3. In the original allocation, total workmen was 313 and in optimum allocation, we are allocating 267 workmen and 46 workmen will be in the system as **factor of safety**.

Conclusions

1. If we make use of scientific approach of resource allocation, we would be able not only to achieve enhanced productivity, but also to remain in a position to retain the factor of safety e.g, in the present study, rest 46 workmen can be adapted to the system to protect it from the various practical situations such as absenteeism, power failure, shortage of raw material, break-down of machines etc.
2. From the table no. 3, it is clear that the reallocation of manpower in a different types of operations needs the development of the **multi-skill** workmen with **additional incentives** like **productivity-linked-incentives** (PLI).
3. Unless we make use of optimum utilization of all business resources, we will not be able to offer quality products at competitive prices in the present day scenario.

Table 3

	Op1	Op2	Op3*	Op4*	Op5*	Op6*	Op7*	Op8	Op9	Op10	Op11	Op12*	Op13*	Production achieved (metric tons)
Present allocation of human resources in different operations (in number of heads)	60	45	8	4	5	6	10	27	60	30	24	4	30	143.9
Optimum allocation of human resources in different operations (in number of heads)	42	12	8	4	5	6	10	20	42	21	72	4	21	343.38

* These are the areas of operations where we can not reduce the man power for proper functioning.

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