Operations Research: The Science and Art of Optimization

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ABSTRACT

Optimization is a buzzword in the industry today. Optimization means 'to make an optimum utilisation of resources'. In the present era of global and cut-throat competition, only those business enterprisescan survive and grow which follow the policy of optimization. The organisations are investing heavily in their infrastructures, in order to manage their business effectively. Every economy has scarce natural resources. In order to strengthen the pace of economic development, optimum utilisation of these resources becomes all the more vital. Taking the field of finance, the concept of optimum capital structure is all the more essential. It is only after having an optimal capital structure that a business can make efficient utilisation of its funds. A business enterprise has to face various problems like assignment of people on jobs, transportation of goods, replacement of articles, minimisation of costs, maximisation of profits, network analysis, queuing problem and many more. All these problems can be solved quantitatively by following the concept of optimization which includes various mathematical techniques for different kinds of problems under the subject of 'Operations Research'. This paper throws light on various applications of optimization theory in mathematics, engineering design, computer science, finance, business and health care. The inns and outs of these techniques will be discussed to help the organisations to do the best in their respective areas.

INTRODUCTION

Optimization is being used by all of us, although we are not aware of the term. One has to take certain decisions for himself and for others. A student has to decide which course he should choose for study. A person seeking employment has to decide which job he should choose for service. Therefore, one has to develop his talents in such a way that he is in a position to take a correct decision at a proper time. An effective decision depends on many factors, which may be economic, social and political. For example starting of a new factory at a place would depend on economic, factors such as construction costs, labour costs, availability of raw materials, transportation costs, taxes, energy, pollution control costs etc. On the other hand, starting of a new Management Institute in a state would depend on the number of students available for further studies and also on state and local politics. Decision making in business and industry is very difficult since it affects many people. In business, the decision-maker is not only faced with a large number of if interacting variables but has to take into account the actions of the other competitions, over which he has no control. Both the quantitative and qualitative (i.e. intuition, experience, common sense, facts, figures and data) analyses are required to make most economical decision. Undoubtedly, we can say, we always try to make best of the deal. Here comes the need of the concept of optimization. The science and art of optimization is termed as 'Operations Research'. Operations research has gained significance in applications like lean production, world-class manufacturing system

(WCM), Benchmarking, Just-in Time (JIT) inventory techniques. It is an approach to problems of how to co-ordinate and control the operations within an organisation. Following is an example to understand the concept clearly.

In order to run an organisation effectively as a whole the problemarises frequently is of co-ordination among the conflicting goals of its various functional departments. Consider the problem of stocks of finished goods. The various departments of the organisation may like to handle this problem differently. To the marketing department, stock of large variety of products is a means of supplying the company's customers with what they want and where they want it. Clearly the fully stocked ware-house is of prime importance to the company. The production department argues for long production runs preferably on a smaller product range, particularly if there is a significant time loss when production is switched from one variety to another. On the other hand, the finance department sees stocks kept as capital tied up unproductively and argues strongly for their reduction. Finally the personnel department sees great advantage in labour relations if there is a steady level of production leading to steady employment. To optimise the whole system, the decision maker must decide the best policy keeping in view the relative importance of objectives and validity of conflicting claims of various departments from the perspective of whole organisation.

In simple words, optimization means making the best of anything, whether it is physical resources or human resource, Optimization is to make perfect, effective or functionally viable use of resources.

ORIGIN AND HISTORY

During World War II, Britain was having very limited military resources, an urgent need was felt to allocate the scarce resources in an effective manner to the various military operations and to the activities within each operation. Therefore the British and the American military management invited large number of scientists to apply a scientific approach to many strategic and tactical problems. Their efforts were instrumental in winning the 'Air Battle of Britain', 'Battle of North Atlantic' and the 'Island Campaign' in the Pacific. The name "Operations Research (O.R.) came directly from the context in which it was used and developed viz. 'Research on Military Operations'.

At the end of World War II, the scientists of this group moved to different sections. eg., transportation, health, education etc. with a conviction that the operations under the control of management can be analysed scientifically and the optimum method for carrying out operations can be investigated.

In India, OR got its formal recognition with the formation of O.R. society in 1957. The society became the member of the International Freedom of O.R. scientists in 1959. The publication of the journal OPSEARCH by ORSI in 1964 further added to the growth of O.R. activities in India.

In recent years, Operations Research has had an increasingly great impact on the management of organisation. Both the number and variety of its applications continue to grow rapidly. The subject is also being used widely in other types of organisations, including business and industry. Many industries including aircraft and missile, automobile, communication, computer, electronics, mining, paper, petroleum and transportation made wide

spread use of O.R. in determining their strategical decisions scientifically. In addition to it, the subject has been used by industries, the financial institutions, government agencies and hospitals also.

"According to D.W. Miller and M.W. Starr,"O.R. is applied design theory. It uses any scientific, mathematical or logical means to attempt to cope with the problems that confront the execute when he tries to achieve a thoroughgoing rationality in dealing with his decision problems."

THE OPERATIONS REASEARCH APPROACH

O.R. represents an integrated framework to help make decision. To have clear understanding of this framework the following sequential steps are to be kept in mind:

1. Orientation
2. Problem definition
3. Data collection
4. Model formulation
5. Solution
6. Model validation and Output analysis
7. Implementation and Monitoring

A brief summary of steps, process activities and process output is presented below.

Process Steps	**Process Activities**	**Process output**
Step I Observe the problem environment	Visits Conferences Observations Research	Sufficient information and support to proceedand nature of solution requested
Step II Define and analyse the problem	Define objectives Define limitations	Model that works under stated
Step III Develop a Model	Define interrelationships Formulate equations Use known O.R. model Search alternate model	environmental constraints
Step IV Select Appropriate data input	Analyze internal-external data Analyse fact Collect opinions Use computer data banks,	Sufficient inputs to operate and test model Solution that supports current organisational objectives
Step V & VI Provide a solution Qualified the model	Test the model Final limitations Update the model	Improved working and Management

Process Steps	Process Activities	Process output
Step VII Implement the Solution	Resolve behavioural issues Sell the idea and give explanations Get Management involved	support for long run operations of model.

- A well defined approach to optimization begins with a rigorous description of the following key elements of any optimization problem.
- Decision variables, which are numerical representations of the available actions or choices. Examples include production levels, price settings, and capital or human resources allocations.
- An objective that is the goal of the optimization, something to be achieved. This goal must be measureable. Examples include maximising profit, minimising distance travelled and minimising unused raw materials.
- Constraints specifying requirements or rules, placing limits on how the objective can be purchased by limiting the permissible values of the decision variables. Some examples are machine processing capacity per hour, customer demand by sales territory, raw materials availability and bill of material in manufacturing or assembly and budgetary restrictions.

The process of optimization usually flows like: Raw data->Standard Reports ->Adhoc Reportsand OLAP -> Descriptive Modelling -> Productive Modelling -> Optimisation Modelling. Each stage forms the foundation upon which the next stage is built. And each stage adds value to the data and information received from the preceding stages.

MAJOR TECHNIQUES OF OPTIMIZATION

Some of the most commonly used techniques by a progressive management in decision-making process are:

1. Linear programming- Allocation of Resources, Asset management
2. Decision Theory - How to make decisions in deterministic probabilistic environments
3. Network Theory- Use of CPM and PERT for the purpose of planning, analysing, scheduling and controlling the progress.
4. Inventory Control- Controlling the inventory, how much to produce, finding lead time, recorder level etc. How to minimize the sum of three conflicting inventory costs. Carrying cost, Storage costs and Ordering costs.
5. Queuing Theory- How to reduce waiting time of customers, when to establish new counter for facility

6. Sequencing: To determine a sequence of performing given jobs if the objective is to minimize the total efforts.
7. Game theory: For assessing the impact of a decision on one's competitors.
8. Simulation: It is a process of designing an experiment which will duplicate or presentnearly as possible the real situation and then watching it what does happen.
9. Transportation Problem: For transporting goods from one place to another.

APPLICATIONS OF OPTIMIZATION

Whenever there is a problem of optimization there is a scope of application of techniques of O.R.

1. **In Industry:** In the field of industrial management, there is a chain of problems starting from the purchase of raw materials to the dispatch of finished goods. The management is interested in having an overall view of the method of optimizing profits. The various operations or processes are:

    - What is to be manufactured?
    - What amount of raw material will be available for production?
    - What, how and when to purchase it at the minimum procurement cost?
    - What amount of raw material will be used for the production? And how it is to be allocated or optimum allocation of limited resources such asmen, machines, materials, time and money.
    - What amount is to prepared, keeping the constraints of resources and costs in mind?

    Above questions come under the category of Asset allocation, where the techniques of linear programming can be used.

    - Who will prepare the product? (Assigning right job to right person). (Assignment model)
    - Where the finished goods will be stored? (Transportation model)

    Project scheduling: By what time the project will he completed, and finding out the critical activities, the activities which the organization, cannot afford to he delayed. (PERT-CPM)
    Selection of advertising media. Demand forecast and stock levels. To decide best time to launch a particular product
    Inventory management: How much to prepare and when identifying the safety stock, reorder level. (Inventory Model)

    Location and size of warehouse or new plant distribution centers and retail outlets. . Manpower planning, wage salary administration. Determining optimal number of persons for each service centre.

    So in the nut shell, the organization uses the techniques of optimization in all the four major departments of organization viz. purchasing, procurement, exploration, in production management, project planning. Marketing management and personnel management.

2. **Engineering design:** Optimization theory provides a formal basis for decision making in a Variety of applications in engineering design Engineering Optimization aims to serve all disciplines within the engineering community. The major areas of concern in this are: planning, design, construction and operation. Find out the optimal design of the product to be manufactured. Making efficient usage of the resources for that particular machine and product. Steel industry in India is using the techniques of Operation research in finding product mix, inventory management, and optimizations of designs, allocation and transportation of goods.

3. **Health Care:** Health care industry is also using the techniques of operations research for its operations, some of the operations are the same as that of any of the business organization, like buying raw materials like bandages etc., allocation of right person to the right job. But the health care sector is implementing these OR techniques to simultaneously reduce cost and improve quality of care, contradicting the notion that improving quality and cost of health care has to involve trade-offs. The various operations in health sector, where optimization is required are:

   1. Assignment of right doctor to the patient.
   2. Assignment of Rooms to the patients.
   ,3. How to reduce wailing time of the patients?
   4. Finding out the location for the health centre.
   5. Designing the medicine depending on the material used and its cost.

   The Institute for Healthcare Optimization (IHO) is workingin this direction and is focused on bringing the science and practice of operations management to healthcare delivery Some times in| rural areas due to lack of knowledge and non availabilityof medical centers in the near by areas the patients, fail to get the medical aid at the earliest, and in the meanwhile the disease increases in many fold and it becomes unable to provide remedial action for the same. The Preventive Health CareFacility Location (PHCFL) problem is to identify optimal locations for preventive health care facilities so as to maximize f participation. People should have more flexibility to select service locations Preventive health care programs aim to save lives and contribute to a better quality of life by diagnosing seriousmcdical conditions early and reducing the likelihood of life-threatening disease. Evidence shows that successful treatment of some health problems is more likely if an illness is diagnosed at an early stage. Facility location decisions, area critical element in strategic planning in preventive health care programs.

4. **Computer Science**- The field of computer science is using the optimization for hardware as well as software optimization.In hardware, it deals with processor, memory and other hardware resources, whereas in case of software optimization,we deal with designing software which will run by utilizing the system resources to maximum optimal level possible. Compiler optimization is the process of tuning the output of a compilor to minimize or maximize some attributes of an executable computer program. The most common requirement is to minimize the time taken to execute a program, a less common one is to minimize the amount of memory occupied. The growth of portable computers has created a market for minimizing the power consumed by a program. Compilor optimization is generally implemented using a sequence or optimizing transformations, algorithms which take a program and transform it to produce an output program that uses resources. Routing problems in case of networking arc also using the concepts of finding shortest distance from source to destination, finding flow of data through a particular channel.

Program optimization or Software optimization is the processof modifying a software system to make some aspect of it work more efficiently or use fewer resources. In general, a computer program may be optimized so that it executes more rapidly, is capable of operating with less memory storage or other resources, or draw less power.

Here the concept of code Optimization which is the process of transforming a piece of code to make more efficient (either in terms of time or space) without changing its output or sideffects. The only difference visible to the code's user should be that runs faster and / or consumes less memory.

Computational tasks can be performed in several different ways with varying efficiency. For example, consider the following C code whose intention is to obtain the sum of all integers from 1 to n:

```
int i, sum = 0;
for i=1;i,=n;i++)
t=4*i;
sum=i+t;
printf("sum:%d\n",sum);
```

in the above code t is calculated n number of times, which will lead to wastage of processing time. This code can be rewritten

```
int, sum=0;
t=4*i;
for(i=1;i,<=n;i++)
sum=i+t;
printf("sum:%d\n",sum);
```

Search engine optimization (SEO) is the process of improving visibility of a website or a web page in search engine. In generalthe site listed first will attract the more visitors. Optimizing a website may involve editing its content and associated coding of both increase its relevance to specific keywords and to remove barriers in between. Promoting a site to increase the number of clicks. The acronym "SEO" can refer to "search engin

optimizers." a term adopted by an industry of consultants to carry out optimization projects on behalf of clients, and by employees who perform SEO services in-house.

Search engineoptimizers may offer SEO as a stand-alone service or as a part of a broader marketing campaign.Resource optimization: The techniques of OR can be applied for allocation of resources (like the job done by operating system, operating system perform job of resource allocation to various processes (here, resource may be Input/output device, memory, processor time).

5. **Agriculture:** With population explosion and subsequent shortage of food every country is facing the problem of optimum allocation of land to various crops in accordance with climatic conditions and available facilities. The problem of optimal distribution of water from various water resources is faced by each developing country and a good amount of research can be done in this direction.

ROLE OF COMPUTERS

Use of a digital computer has become an integral part of the O.R. approach to decision-making. The computer may be required due to the complexity of the model, volume of data required or the computations to be made. In other words, computer in today's scenario has become an indispensable tool for solving Operations Research problems. Many O.R. techniques are available today in the form of 'canned' programmes.

The O.R. problems are time consuming and involve tedious computations. Even a simple problem with few variables take a long time to solve manually and even by a hand calculator. For a highly complex, real life business problem, the task of performing computations, even with a hand calculator, is simply out of question. For this reason many of the techniques were not widely used until 60's. The advent of computers accelerated the wide use of O.R. techniques for solving complex business problems faced by managers and administrators in business and government. Computers provide the much needed computational support for many of these techniques. The automation of computational algorithm allows decision-makers to concentrate on problem's formulation and the interpretation of the solutions. Major computer manufacturer and vendor have developed software packages for the various computer systems providing computational support for problems to be solved V the application of O.R. techniques. Further, commercial software houses and academic departments in universities have also produced software packages for solving the various Operations Research problems. Computer manufacturers like IBM, CDC, Honeywell, UNIVAC, ICL, etc. have invested substantial amounts in developing software programs for solving the optimizing, scheduling, inventory, simulation and other Operations Research problems. The role of computers in solving current as well as future problems can be explained with the help of following example:

Most of linear programming models (of even a small-scale industry) involve 200 to 300 decision variables with 10 to 200 constraints. It is believed that most of the business problems particularly the blending problems of oil refineries will result an LP model with 4,000 to 5,000 variables and 3,000 to 3,500 constraints. The problem of such a magnitude is virtually impossible to solve through manual computations. Such type of a problem may be solved by application of sophisticated software packages, e.g., IFP/OPTIMUM, developed' by EXECUCOM

Systems Corporation, Austin in Texas. The aforesaid package may be used to solve a linear programming, integer programming and non-linear programming problem with large number of variables and constraints. In addition to finding optimal solution, IFPS (Interactive Financial Planning System) OPTIMUM package can be directed to perform post-solution analysis in two parts, viz., DECISION ANALYSIS and CONSTRAINT ANALYSIS.

GROWTH OF OPERATIONS RESEARCH IN DIFFERNET SECTORS

The sincere efforts were made by National productivity council, National Industrial Development corporation, Administrative Staff College Hyderabad, and Indian Institutes of Management etc. in the direction of accepting O.R. methods. Organised industries in India are becoming conscious of the role of O.R. and a good number of them have well-trained O.R. teams. Some of these organisations are 'Indian Airlines', Railways, Defence organisation, Fertiliser Corporation of India, Hindustan Steel Ltd., Tata Iron and Steel Co., TELCO, DCM, CSIR, STC, BHEL, SAIL, ONGC, etc. Assignment models have been used by Kirloskar company for allocation of their salesmen to different areas so as to maximize the profit. Linear programming models have been used to assemble various diesel engines at the lowest possible cost. D.C.M, Calico and Binny's have been using LP models for cotton blending. A number of organisations are utilising OR techniques for solving problems related to staffing, production planning, blending, product mix, maintenance, inspection, advertising, capital budgeting, investment and the like.

CONCLUSION

To survive in the wide-spread global competition and dynamic market scenarios, there is a high pressure on the management to make economic decision. One of the essential managerial skills is the ability to allocate and utilise resources appropriately in the efforts of achieving the optimal performance efficiently. Decision-makers have to consider a large number of factors and large amount of data while taking the decision. Operations research techniques can be very helpful in such situations and the success stories of implementation of OR techniques in India and abroad has proved this thing that these techniques can be a boon for the industry. Also the availability of software packages have increased the benefits of OR to many fold. The future of OR is very promising and its proper implementation and usage will prove to be a harbinger of success for every organisation in any sector.

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