Operations Research : A Brief Introduction

Himadri Barman

Operations correspond to a set of activities undertaken to realize a desired objective. Operations Research is an experimental and applied science devoted to observing, understanding and predicting the behavior of purposeful man-machine systems; and operations research workers are actively engaged in applying this knowledge to practical problems in business, government and society (Operations Research Society of America). In my view, Operations Research (OR) is the application of quantitative methods and models devoted to the optimisation of resource utilization to carry out particular tasks or to solve a given problem.

OR had its beginning in World War II. The term was coined by McClosky and Trefthen in 1940 in the small town of Bowdsey in UK. OR played a significant role in the victory of the Allied forces in the great war by optimizing the use of scarce and dwindling resources. The stupendous success of OR generated interest in it to solve problems of the government and the industry which have an interest in the optimization of resources and solution of complex problems. The first book on the subject, Methods of Operations Research by Morse and Kimball was published in 1951. Operations Research Society of America came into existence in 1952. India is one of the countries which have been a pioneer in using OR. The OR Society of India was formed in 1955 and is one of the first members of the International Federation of OR Societies, which was founded in 1959. Today, OR is a popular subject in management and mathematics education and is used extensively in industrial establishments.

Industries are interested in OR because of the complexity of the problems they have to encounter and the uncertainty of the business environment in which they operate. OR finds use in Accounting (cash flow planning, credit policy analysis), Construction (project management), Facilities Planning (location of warehouses, logistics), Finance (investment and portfolio analysis), Manufacturing (inventory control, production scheduling), Marketing (selection of product mix), Human Resource (HR planning), Purchasing (ordering of materials), Research & Development, etc.

Advantages of Operations Research

- Better Decisions
- Better Coordination
- Better Control
- Better System

Disadvantages of Operations Research

- Requirement of Skilled Manpower
- Requirement of Quality Data
- Computationally Intensive
- Money and Time Constraints
- Implementation

Phases of Operations Research

- Observe the Problem Environment
- Analyse and Define the Problem
- Develop a Model
- Select Appropriate Data Input
- Provide a Solution and Test Reasonableness
- Implement the Solution

The Concept of Models

Modelling in its broadest sense is the cost effective use of something in place of something else. A model represents reality for the given purpose; the model is an abstraction of reality in the sense that it cannot represent all aspects of reality. Any model is characterized by three essential attributes: reference, purpose and cost-effectiveness.

There are various models that are used in the application and study of different disciplines. OR also uses many of them. They are broadly classified as:

- **Models by Structure**: Iconic, Analogue and Mathematical
- **Models by Nature of the Environment**: Deterministic and Stochastic
- **Models by Function**: Descriptive, Predictive and Normative
- **Models by the Extent of Generality**: Specific (Static and Dynamic) and General (Simulation and Heuristic)

The various models are being described below. They are not exclusive in nature in the sense that a particular model that is being used may be classified into more than one type. For e.g, Linear Programming Problems fall into Mathematical, Deterministic as well as Normative model.

- **Iconic (Physical) Model–** physical / pictorial representation of various aspects of a system. E.g., Model of a car
- **Analogue (Schematic) Model** – it uses a set of properties to represent another set of properties which a system under study has. E.g. Organisational Charts
- **Mathematical (Symbolic) Model** – It uses a set of symbols to represent the decision variables of a problem under consideration. E.g., Linear Programming Problems. **Analytic Models** are mathematical models where exact solution are obtained by mathematical methods in closed form
- **Deterministic Model** – Here, everything is certain. E.g., Assignment Problems
- **Stochastic (Probabilistic) Model** – Here, uncertainty is an important aspect. E.g., Stochastic Inventory Problems
- **Descriptive Model** – It just describes a system / situation. E.g., Opinion Poll
- **Predictive Model** – A model is created or chosen to try to best predict the probability of an outcome
- **Normative (Optimisation) Model** – Prescriptive in nature and develop objective decision rules for optimum solutions
- **Static Model** – It assumes that variables are constant w.r.t time. E.g., Transportation Problems

- **Dynamic Model** – It considers time as an important variable. E.g, Dynamic Programming Problems
- **Simulation Model** – A representation of reality through the use of a model or device which will react in the same manner as reality under a given set of conditions
- **Heuristic Model** – Based on experience

Characteristics of a Good Model

- Reasonably Simple and Highly Accurate
- Flexible to account for new information / changes
- Limited Assumptions
- Less Number of Variables
- Open to Parametric Treatment

Solving Operations Research Problems

- **Analytic Procedure** – Use classical mathematical techniques like differential calculus
- **Iterative Procedure** – Start with a trial solution and improve upon that till no further improvement is possible
- **Monte-Carlo Technique** – Take sample observations, compute probability distributions for the variable using random numbers and construct some functions to determine values of the decision variables.

Linear Programming Problems

LPP deals with the optimization (maximisation or minimisation) of a function of variables known as the objective function subject to a set of linear equalities and/or inequalities known as constraints. The graphical method of solving a LPP is applicable where two variables are involved. The most widely used method for solving LP problems consisting of any number of variables is called Simplex Method developed by George Dantzig in 1947.

Some important concepts related to LPP are briefed below:

- A set of values $X_1, X_2,\ldots, X_n$ which satisfies the constraints of the LPP is called its *solution*.
- Any solution which satisfies the non-negativity constraints of the LPP is called its *feasible solution*.
- Any solution which optimises the objective function of the LPP is called its *optimal solution*.
- Given a system of *m* linear equations with *n* variables (m<n), any solution which is obtained by solving for *m* variables keeping the remaining *(n – m)* variables zero is called a *basic solution*. The *m* variables are called *basic variables*.
- A basic feasible solution is a basic solution which satisfies the non-negativity constraints. Basic feasible solutions are of two types: *Non-degenerate* where none of the basic variables are zero and *Degenerate* where at least one of the basic variables is zero.
- If the value of the objective function may be increased or decreased indefinitely, the LPP is said to have unbounded solution.

Standard Form of LPP

- Objective function is of maximisation type
- All constraints are expressed as equations
- Right hand side of each constraint is non-negative
- All variables are non-zero

References

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