OPERATIONS RESEARCH - MEANING FEATURES LIMITATIONS

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INTRODUCTION

Application of mathematical (quantitative) techniques to decision making In OR, a problem is first clearly defined and represented (modeled) as a set of mathematical equations. It is then subjected to rigorous computer analysis to yield a solution (or a better solution) which is tested and re-tested against real-life situations until an optimum solution is found. OR applies different approaches to different types of problems: dynamic programming, linear programming, and critical path method are used in handling complex information in allocation of resources, inventory control, and in determining economic reorder quantity; forecasting and simulation techniques such as Monte Carlo method are used in situations of high uncertainty such as market trends, next period's sales revenue, and traffic patterns. Also called decision science, management science, or operational research.

Operational Research (OR) is the use of advanced analytical techniques to improve decision making. It is sometimes known as Operations Research, Management Science or Industrial Engineering. People with skills in OR hold jobs in decision support, business analytics, marketing analysis and logistics planning – as well as jobs with OR in the title.

IMPORTANCE OF OPERATIONS RESEARCH

Operations research (OR) is a management function that draws extensively from the divisions of mathematics and science. It makes use of algorithms, statistics and numerous modeling techniques from mathematics to find the best possible solutions for complex problems. In OR, the maxima has to be optimized and the minima has to be reduced for all the objects involved. Maxima are usually the yield, performance and profit and minima are the losses and risks.

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THERE ARE MANY REASONS TO USE OR.

Business Operations

- OR could be very effective in handling issues of inventory planning and scheduling, production planning, financial and revenue management and risk management. Basically, OR could be used in any situation where improvements in the productivity of the business are of paramount importance.

Control

- With OR, organizations are greatly relieved from the burden of supervision of all the routine and mundane tasks. The problem areas are identified analytically and quantitatively. Tasks such as scheduling and replenishment of inventories benefit immensely from OR.

Decision Making

- OR is used for analyzing problems of decision making in a superior fashion. The organization can decide on factors such as sequencing of jobs, production scheduling and replacements. Also the organization can take a call on whether or not to introduce new products or open new factories on the basis of a good OR plan.

Coordination

- Various departments in the organization can be coordinated well with suitable OR. This facilitates smooth functioning for the entire organization.

Systems

- With OR, any organization follows a systematic approach for the conduct of its business. OR essentially emphasizes the use of computers in decision making; hence the chances of errors are minimum.

Examples of OR in action

- **Scheduling:** of aircrews and the fleet for airlines, of vehicles in supply chains, of orders in a factory and of operating theatres in a hospital.
- **Facility planning:** computer simulations of airports for the rapid and safe processing of travellers, improving appointments systems for medical practice.
- **Planning and forecasting:** identifying possible future developments in telecommunications, deciding how much capacity is needed in a holiday business.
- **Yield management:** setting the prices of airline seats and hotel rooms to reflect changing demand and the risk of no shows.

- **Credit scoring:** deciding which customers offer the best prospects for credit companies.
- **Marketing:** evaluating the value of sale promotions, developing customer profiles and computing the life-time value of a customer.
- **Defence and peace keeping:** finding ways to deploy troops rapidly.

METHODS USED WITH OR:

1. **Linear Programming:**

A typical mathematical program consists of a single objective function, representing either a profit to be maximized or a cost to be minimized, and a set of constraints that circumscribe the decision variables. In the case of a linear program (LP) the objective function and constraints are all linear functions of the decision variables. At first glance these restrictions would seem to limit the scope of the LP model, but this is hardly the case. Because of its simplicity, software has been developed that is capable of solving problems containing millions of variables and tens of thousands of constraints. Countless real-world applications have been successfully modeled and solved using linear programming techniques.

2. **Network Flow Programming**

The term network flow program describes a type of model that is a special case of the more general linear program. The class of network flow programs includes such problems as the transportation problem, the assignment problem, the shortest path problem, the maximum flow problem, the pure minimum cost flow problem, and the generalized minimum cost flow problem. It is an important class because many aspects of actual situations are readily recognized as networks and the representation of the model is much more compact than the general linear program. When a situation can be entirely modeled as a network, very efficient algorithms exist for the solution of the optimization problem, many times more efficient than linear programming in the utilization of computer time and space resources.

3. **Integer Programming**

Integer programming is concerned with optimization problems in which some of the variables are required to take on discrete values. Rather than allow a variable to assume all real values in a given range, only predetermined discrete values within the range are permitted. In most cases, these values are the integers, giving rise to the name of this class of models.

Models with integer variables are very useful. Situations that cannot be modeled by linear programming are easily handled by integer programming. Primary among these involve binary decisions such as yes-no, build-no build or invest-not invest. Although one can model a binary decision in linear programming with a variable that ranges between 0 and 1, there is nothing that keeps the solution from obtaining a fractional value such as 0.5, hardly acceptable to a decision maker. Integer programming requires such a variable to be either 0 or 1, but not in-between.

Unfortunately integer programming models of practical size are often very difficult or impossible to solve. Linear programming methods can solve problems orders of magnitude larger than integer programming methods. Still, many interesting problems are solvable, and the growing power of computers makes this an active area of interest in Operations Research.

4. Nonlinear Programming

When expressions defining the objective function or constraints of an optimization model are not linear, one has a nonlinear programming model. Again, the class of situations appropriate for nonlinear programming is much larger than the class for linear programming. Indeed it can be argued that all linear expressions are really approximations for nonlinear ones.

Since nonlinear functions can assume such a wide variety of functional forms, there are many different classes of nonlinear programming models. The specific form has much to do with how easily the problem is solve, but in general a nonlinear programming model is much more difficult to solve than a similarly sized linear programming model.

5. Dynamic Programming

Dynamic programming (DP) models are represented in a different way than other mathematical programming models. Rather than an objective function and constraints, a DP model describes a process in terms of states, decisions, transitions and returns. The process begins in some initial state where a decision is made. The decision causes a transition to a new state. Based on the starting state, ending state and decision a return is realized. The process continues through a sequence of states until finally a final state is reached. The problem is to find the sequence that maximizes the total return.

The models considered here are for discrete decision problems. Although traditional integer programming problems can be solved with DP, the models and methods are most appropriate for situations that are not easily modeled using the constructs of mathematical programming. Objectives with very general functional forms may be handled and a global optimal solution is always obtained. The price of this generality is computational effort. Solutions to practical problems are often stymied by the "curse of dimensionally" where the number of states grows exponentially with the number of dimensions of the problem.

6. Stochastic Programming

The mathematical programming models, such as linear programming, network flow programming and integer programming generally neglect the effects of uncertainty and assume that the results of decisions are predictable and deterministic. This abstraction of reality allows large and complex decision problems to be modeled and solved using powerful computational methods.

Stochastic programming explicitly recognizes uncertainty by using random variables for some aspects of the problem. With probability distributions assigned to the random variables, an expression can be written for the expected value of the objective to be optimized. Then a variety of computational methods can be used to maximize or minimize the expected value. This page provides a brief introduction to the modeling process.

7. Combinatorial Optimization

The most general type of optimization problem and one that is applicable to most spreadsheet models is the combinatorial optimization problem. Many spreadsheet models contain variables and compute measures of effectiveness. The spreadsheet user often changes the variables in an unstructured way to look for the solution that obtains the greatest or least of the measure. In the words of OR, the analyst is searching for the solution that optimizes an objective function, the measure of effectiveness. Combinatorial optimization provides tools for automating the search for good solutions and can be of great value for spreadsheet applications.

8. Stochastic Processes

In many practical situations the attributes of a system randomly change over time. Examples include the number of customers in a checkout line, congestion on a highway, the number of items in a warehouse, and the price of a financial security, to name a few. When aspects of the process are governed by probability theory, we have a stochastic process.

The model is described in part by enumerating the states in which the system can be found. The state is like a snapshot of the system at a point in time that describes the attributes of the system. The example for this section is an Automated Teller Machine (ATM) system and the state is the number of customers at or waiting for the machine. Time is the linear measure through which the system moves. Events occur that change the state of the system. For the ATM example the events are arrivals and departures.

In this section we describe the basic ideas associated with modeling a stochastic process that are useful for both Discrete and Continuous Time Markov Chains

- **Discrete Time Markov Chains**

  Say a system is observed at regular intervals such as every day or every week. Then the stochastic process can be described by a matrix which gives the probabilities of moving to each state from every other state in one time interval. Assuming this matrix is unchanging with time, the process is called a Discrete Time Markov Chain (DTMC). Computational techniques are available to compute a variety of system measures that can be used to analyze and evaluate a DTMC model. This section illustrates how to construct a model of this type and the measures that are available.

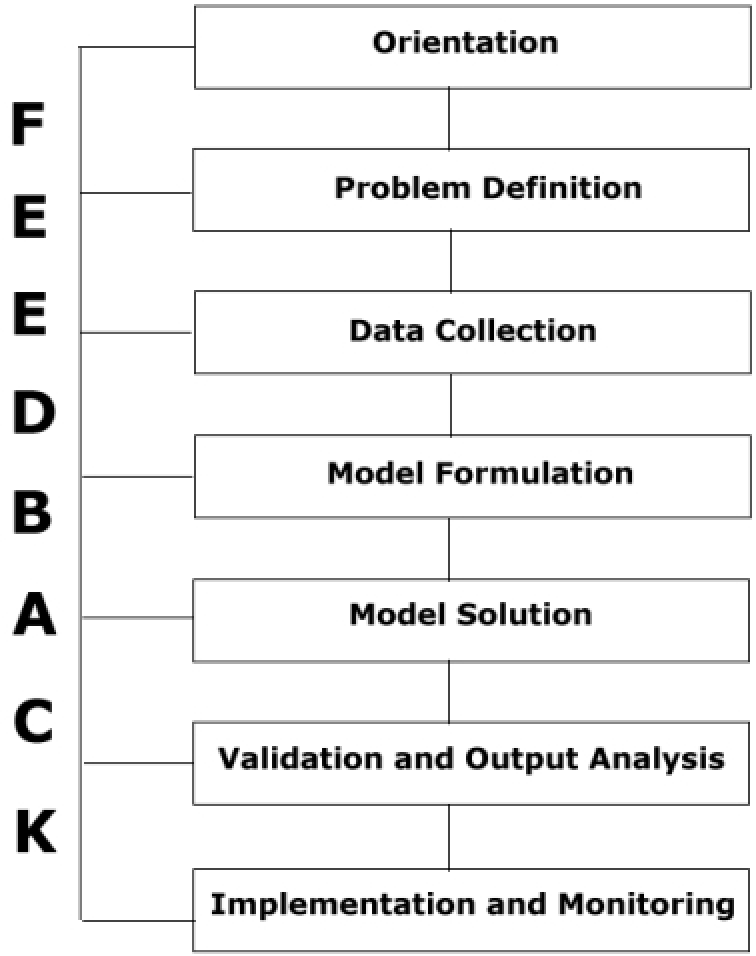
- **Continuous Time Markov Chains**

Here we consider a continuous time stochastic process in which the duration of all state changing activities are exponentially distributed. Time is a continuous parameter. The process satisfies the Markovian property and is called a Continuous Time Markov Chain (CTMC). The process is entirely described by a matrix showing the rate of transition from each state to every other state. The rates are the parameters of the associated exponential distributions. The analytical results are very similar to those of a DTMC. The ATM example is continued with illustrations of the elements of the model and the statistical measures that can be obtained from it.

9. **Simulation**

When a situation is affected by random variables it is often difficult to obtain closed form equations that can be used for evaluation. Simulation is a very general technique for estimating statistical measures of complex systems. A system is modeled as if the random variables were known. Then values for the variables are drawn randomly from their known probability distributions. Each replication gives one observation of the system response. By simulating a system in this fashion for many replications and recording the responses, one can compute statistics concerning the results. The statistics are used for evaluation and design.

THE OPERATIONS RESEARCH APPROACH



The prevalence of operations research in the Nation's economy reflects the growing complexity of managing large organizations that require the effective use of money, materials, equipment, and people. Operations researches analysts help determine better ways to coordinate these elements by applying analytical methods from mathematics, science, and engineering. They solve problems in different ways and propose alternative solutions to management, which then chooses the course of action that best meets the organization's goals. In general, operations research analysts may be concerned with diverse issues such as top-level strategy, planning, forecasting, resource allocation, performance measurement, scheduling, design of production facilities and systems, supply chain management, pricing, transportation and distribution, and analysis of data in large databases.

ADVANTAGES OF OPERATION RESEARCH:

1. **Effective Decisions**

Operations Research (OR) helps the managers to take better and quicker decisions. It increases the number of alternatives. It helps the managers to evaluate the risk and results of all the alternative decisions. So, OR makes the decisions more effective.

2. **Better Coordination**

Operations Research (OR) helps to coordinate all the decisions of the organisation. It coordinates all the decisions taken by the different levels of management and the various departments of the organisation. For e.g. It coordinates the decisions taken by the production department with the decisions taken by the marketing department.

3. **Facilitates Control**

Operations Research (OR) helps the manager to control his subordinates. It helps the manager to decide which work is most important. The manager does the most important work himself, and he delegates the less important work to his subordinates.

Operations Research (OR) helps a manager to fix standards for all the work. It helps him to measure the performance of the subordinates. It helps the manager to find out and correct the deviations (difference) in the performance. So, OR facilitates control.

4. **Improves Productivity**

Operations Research (OR) helps to improve the productivity of the organisation. It helps to decide about the selection, location and size of the factories, warehouses, etc. It helps in inventory control. It helps in production planning and control. It also helps in manpower planning. OR is used in expansion, modernisation, installation of technology, etc. OR uses many different mathematical and statistical techniques to improve productivity. Simulation is used by many organisations to improve their productivity. That is, they try out many production improvement techniques on a small scale. If these techniques are successful then they are used on a large scale.

DISADVANTAGES:

There are a number of limitations of operations research which may be stated as follows:

1. In the quantitative analysis of operations research, certain assumptions and estimates are made for assigning quantitative values to factors involved. If such estimates are wrong, the result would be- equally misleading.

2. Many management problems do not lend themselves to quantitative measurement and analysis. Intangible factors of any problem concerning human behaviour cannot be quantified accurately and all the patterns of relationships among the factors may not be covered. Accordingly, the outward appearance of scientific accuracy through the use of numbers and equations becomes unrealistic.

3. The quantitative methods of operations research are many cases costly, elaborate and sophisticated in nature. Although complex problems are fit for analysis by tools of operations research, relatively simple problems have no economic justification for this type of quantitative analysis.

4. A knowledge of some concepts of mathematics and statistics is prerequisite for adoption of quantitative analysis by the managers. According to the present training and experience of most managers, the actual use of these tools may be confined to a few cases.

5. Operations research is not a substitute for the entire process of decision making and it does not relieve the managers of their task of decision making. In one phase of decision making viz., selection of best solution through the evaluation of alternatives, operations research comes into the picture.

Managers have to prepare the ground-work for the introduction of operations research through several steps in decision making viz., diagnosis of problem, analysis of problem and development of alternatives; and even after the selection of best solution by operations research, managers have to put the decision into- effect and to institute a system of follow-up.

SUMMARY:

The goal of OR is to develop information to provide valuable insight and guidance. By utilizing OR methods, the objective is to apply to any given project the most appropriate scientific techniques selected from mathematics, any of the sciences including the social and management sciences, and any branch of engineering, respectively. The work normally entails collecting and analyzing data, creating and testing mathematical models, proposing approaches not previously considered, interpreting information, making recommendations, and aiding at implementing the initiatives that result from the study. Moreover, utilizing OR methods allow to develop and implement software, systems, services, and products related to a clients methods and applications. The systems may include strategic decision-support systems, which play a vital role in many organizations today.

References:

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