
UNIT 1: OVERVIEW OF OPERATIONS RESEARCH

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1.0 AIMS AND OBJECTIVES

After completing this unit the student should be able to answer these questions:

- What is management science?
- What advantages does a quantitative approach to problem solving offer?
- What is the importance of knowing management science?
- What is a model and how it is used in management science?
- What is the management science approach to problem solving?

1.1 INTRODUCTION

Management science or operations research uses a logical approach to problem solving. The problem is viewed as the focal point of analysis, and quantitative models are the vehicles by which solutions are obtained. This quantitative approach is widely employed in business. Areas of

application include forecasting, capital budgeting, capacity planning scheduling inventory management, project management and production planning.

In this first unit, some of the basic of management science are covered, included answers to such questions: what is management science? Who uses it? Who use a quantitative approach? What are models and how they used? And what are the different types of models?

1.2 DEFINITION OF MANAGEMENT SCIENCE OR OPERATION RESEARCH

Operations research has been defined so far in various ways and it is perhaps still too young to be defined in some authoritative way. It is not possible to give uniformly acceptable definitions of OR/MS. A few opinions about the definition of OR/MS are given below. These have been changed according to the development of the subject.

Management science: can be defined as a problem solving process used by an interdisciplinary team to develop mathematical models that represent simple to complex functions relationships and provide management with a basis for decision making and a means of uncovering new problems for quantitative analysis.

Moreover, management science encompasses:

- development of models for specific problems
- it makes a substantial contribution in a much broader area: the application of the output from MS models for decision making at the lower, middle, and top management levels
- A manager's experience, upcoming business conditions and the output from a mathematical models form the best combination for planning, organizing, directing and controlling the company's activities.

- **OR** is a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control.
- **OR** is the scientific method of providing executive with an analytical and objective basis for decisions.
- **OR** is the art of giving bad answers to problems to which otherwise, worse answers are given.
- It is a systematic method oriented study of the basic structures, characteristics, functions and relationships of an organization to provide the executive with a sound, scientific and quantitative basis for decision making.
- **OR** is a scientific approach to problem solving for executive management.

Management science: is the application of a scientific approach to solving management problems in order to help managers make better decisions.

As implied by this definition, management science encompasses a number of mathematically oriented techniques that have either been developed within the field of management science or been adapted from other disciplines, such as the natural sciences, mathematics, statistics, and engineering.

Management science: is a discipline devoted to solving certain managerial type problems using quantitative models. This quantitative approach is widely employed in business.

Operation Research: is the application of scientific methods, techniques, and tools to problems involving the operations of systems so as to provide those in control of operations with optimum solutions to the problem. *Churchman et al,*

Thus, it may be regarded as the scientific method employed for problem solving and decision making by the management. The following indicates the significant features of operation research:

- **Decision making**
- **Scientific approach**: it employs scientific methods for the purpose of solving problems, and there is no place of whims and guess-work in it. It is a formalized process of reasoning.
- **Objective**: it attempts to locate the best or optimal solution to the problem under consideration.
- **Inter-disciplinary team approach**: no single individual can have a through knowledge of the myriad aspects of OR and how the problems may be addressed.
- **Digital computer**: use of a digital computer has become an integral part of the operations research approach to decision making.

1.3 MAJOR CHARACTERISTICS OF MANAGEMENT SCIENCE/OPERATION RESEARCH

There are four major characteristics of management science. These are:

1. Examine Functional Relationships From A Systematic Overview

The activity of one function or part of a company will have some effect on the activity of each of the other functions or parts. In order to make effective evaluations of decisions or actions in a company, it is necessary to identify all important interactions and determine their impact on the company as a whole. Initially, the functional relationships in an MS project are expanded deliberately so that all the significantly interacting parts and their related components are contained in a statement of the

problem. A systems overview examines the entire area under the manager's control rather than just one specialized area. This approach provides a basis for initiating inquiries into problems that seem to be affecting performance at all levels.

2. Use The Interdisciplinary Approach

During the early years of management science there was a great shortage of scientists (mathematicians, physicists, chemists, engineers and statisticians). The military groups interested in MS at that time had to hire their personnel not by selection, but by acquisition. Out of this forced approach, management science comes to recognition of the value inherent to the interdisciplinary team. Although we often speak of physical problems, chemical problems, biological problems, psychological problems, social problems and economic problems as though such problems are in some way categorized in nature, the fact is that various disciplines actually describe different ways of studying similar problems.

3. Uncover New Problems For Studying

A third characteristic of MS, one which is often overlooked is that the solution of an MS problem brings new problems to light. All interrelated problems uncovered by the MS approach do not have to be solved at the same time. However, each must be solved with consideration for other problems if maximum benefits are to be obtained. It can be said that management science is never effectively used when it is restricted to "one-shot" projects. Its greatest benefits are those obtained through a continuity of research.

4. Uses A Modeling Process Approach To Problem Solving

MS, like many disciplines, takes a systematic approach to problem solving. Although several approaches to solving MS problems can be advanced, we may stress the modeling process, in which both manager and management scientist interact throughout the problem solving

process. Great emphasis is placed on the participation of both these parties in the modeling of the problem, but before examining the details of the interaction between the manager and the Management Scientist, we will look first at the essentials of mathematical models and consider some of their advantages and disadvantages.

1.4 DECISION MAKING AND RELEVANCE OF OR/MS

The role of quantitative analysis in the managerial decision making process is perhaps best understood by considering the decision making process. Note that the process is initiated by the appearance of a problem. The manager is responsible for making a decision or selecting a course of action will probably make an analysis of the problem, which includes a statement of the specific goals or objectives, an identification of constraints, an evaluation of alternative decisions, and a selection of the apparent "best" decision or solution for the problem.

The analysis process employed by manager may take two basic forms: ***qualitative*** and ***quantitative***.

Qualitative Approach to Decision Making

- o The qualitative analysis is based on primarily upon the manager's judgment and experience.
- o The type of analysis includes the manager's intuitive "feel" for the problem and is more of an art than a science.
- o If the manager has had experience with similar problems, or if the problem is relatively simple, heavy emphasis may be placed up on qualitative analysis.
- o However, if the manager has had little experience with similar problems, or if the problem is sufficiently important and complex, then quantitative analysis of the problem can be a very important consideration in the managers' final decision.

- o It is considered when the decision maker doesn't have data about the problem.
- o The skills in qualitative approach to problem solving are inherent in the decision maker.
- o It is used when the problem under consideration doesn't involve too many variables or it is not complex, it is not new or familiar, when the cost of the decision is not heavy and when immediate action is required.

Quantitative Approach to Problem Solving

- o In this approach, an analyst will concentrate on the quantitative factors or data associated with the problem and develops mathematical expressions that describe the objectives, constraints and relationships that exist in the problem.
- o It is supported by the available data.
- o It uses mathematical models.
- o The skills in quantitative approach is acquired by studying the mathematical tools or OR techniques.
- o It is used under the following situations
 - o When the problem involves too many variables
 - o When the problem is new (not familiar)
 - o When the decision is very important involving a great amount of money
 - o When the problem is repetitive (unique)
 - o This approach is believed to reduce time and effort to make decisions.

Both the qualitative and the quantitative analysis of a problem provide important information for the manager or decision maker. In many cases, a manager will draw upon both sources and, through a comparison and evaluation of the information, make a final decision.

While skills in the qualitative approach are inherent in the manager and usually increase with experience, the skills of the quantitative approach can be learned only by studying the assumptions and methods of management science. A manager can increase decision making effectiveness by learning more about quantitative methodology and by better understanding its contribution to the decision making process. The manager who is knowledgeable in quantitative decision making procedures is in a much better position to compare and evaluate the qualitative and quantitative sources of recommendations and ultimately combine the two sources in order to make the best possible decision.

1.5 OPERATIONS RESEARCH TECHNIQUES

1. Linear Programming Method

It is primarily concerned with optimum allocation of scarce resources subject to certain limitation. It uses simplex procedure to solve product mix in portfolio analysis and transportation algorithm.

2. Decision Analysis (Theory)

It is concerned with making decision under conditions of *risk* and *uncertainty*. Decision theory represents a generalized approach to decision making which often serves as the basis for a wide range of managerial decision making. The decision model includes a list of courses of action that are available and the possible consequences of each course of action. An important factor in making decision is the degree of certainty associated with the consequences. This can range anywhere from complete certainty to complete uncertainty, and it generally affects the way a decision is reached.

3. Network Analysis

It is considered under risk and uncertainty situation, and involves determination of an optimum sequence of performing certain activities in a project - this is to minimize the overall cost (time).

Networks are important tools of management science. Not only can networks are used to models a wide variety of problems they can often be solved more easily than other models of the same problem, and they present models in a visual format.

The techniques in net work analysis includes **PERT, CPM, and Gant Chart.**

4. Inventory Model

It is a model which operates to optimize inventory levels. The main emphasis is minimizing, carrying, ordering and being out of stock costs.

5. Queuing Model (Waiting Line Model)

It determines the average time spent in line waiting for service.

6. Markov Analysis

It is used to determine the purchasing behavior of customers-brand loyalty of customers- given that the behavior of customers is known.

Significance of Operation Research

- o It provides a tool for scientific analysis and provides solution for various business problems.
- o It enables proper deployment and optimum allocation of scarce resources.
- o It helps in minimizing waiting and servicing costs.
- o It enables the management to decide when to buy and how much to buy through the technique of inventory planning.
- o It helps in evaluating situations involving uncertainty.

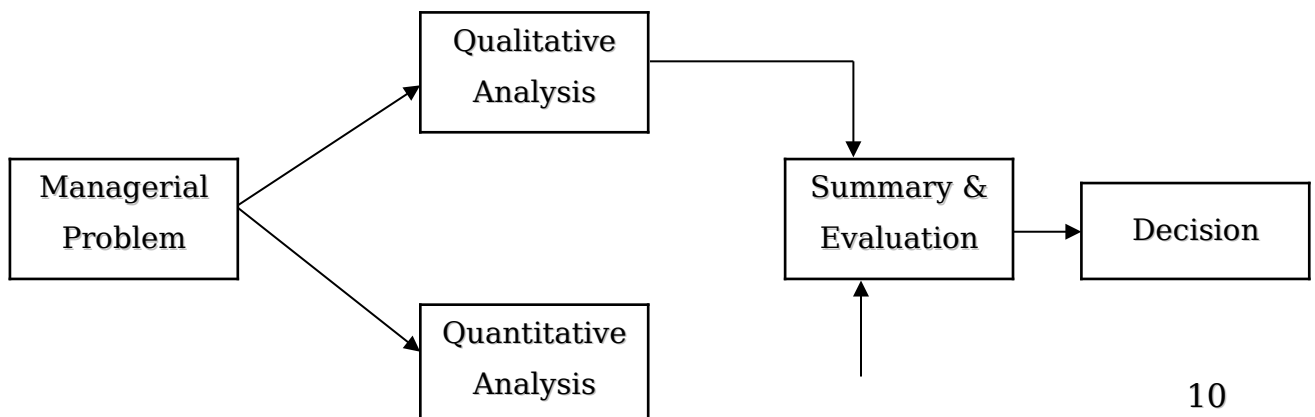
- o It enables experimentation with models, thus eliminating the cost of making errors while experimenting with reality.
- o It allows quick and inexpensive examination of large numbers of alternatives.
- o In general OR facilitates and improves the decision making process.

Areas of Application

- o Inventory control
- o Facility design (distribution decision)
- o Product mix determination
- o Portfolio analysis
- o Allocation of scarce resources
- o Investment decisions (constructing new plant, expanding programs, sub contracting and the like)
- o Project management.

1.6 QUANTITATIVE APPROACH TO DECISION MAKING

The role of quantitative analysis in the managerial decision making process is perhaps best understood by considering the flowchart below:



We begin our study of quantitative approaches to decision making by considering a five step procedure:

1. PROBLEM DEFINITION

The problem definition step is the most critical phase of the quantitative analysis process. It usually takes imagination, teamwork, and considerable effort to transform a rather general problem description in to a well-defined problem that can be approached quantitatively.

2. MODEL DEVELOPMENT

Models are representations of real objects or situations. These representations or models can be represented in various forms. They are constructed to make conclusion about the real thing and show the relationship between an action and reaction or cause and effect. Depending up on the degree of abstraction model is classified in to three formats:

- o *Iconic Model*: it is a physical representation of a system or real object on a different scale than the original.

Example:

- A scale model of an airplane is a representation of a real airplane.
- A child's toy truck is a model of a real truck

- o *Analog Model*: it includes those that are physical in form but doesn't have the same physical appearance as the object being modeled.

Example:

- The speedometer of an automobile is an analog model; the position of the needle on the dial represents the speed of the automobile
- A thermometer is an analog model representing temperature or Barometer for atmospheric pressure.
- o *Mathematical Model*: it is a model which represents a problem or reality by a system of symbols and mathematical expressions.

Example: $TR = PQ$ Given $P = 10$

$$TR = 10Q$$

The purpose or value of any model is that it enables us to draw conclusions about the real situation by studying and analyzing the model. For example, an airplane designer might test an iconic model of a new airplane in a wind tunnel in order to learn about the potential flying characteristics of the full size airplane. Similarly, a mathematical model may be used to draw conclusions about how much profit will be earned if a specified quantity of particular product is sold.

Benefits of Models

- o Experimenting with models saves a lot of time than the real system.
- o Manipulating the model is much easier than manipulating the real system.
- o The cost of making errors during the trial and error experiment is much smaller when done on the model.
- o Model enhances and re-enforces learning
- o Model enables quick identification and analysis of solution.

Mathematical Model

Any mathematical model has three components.

1. The decision variable (controllable inputs)

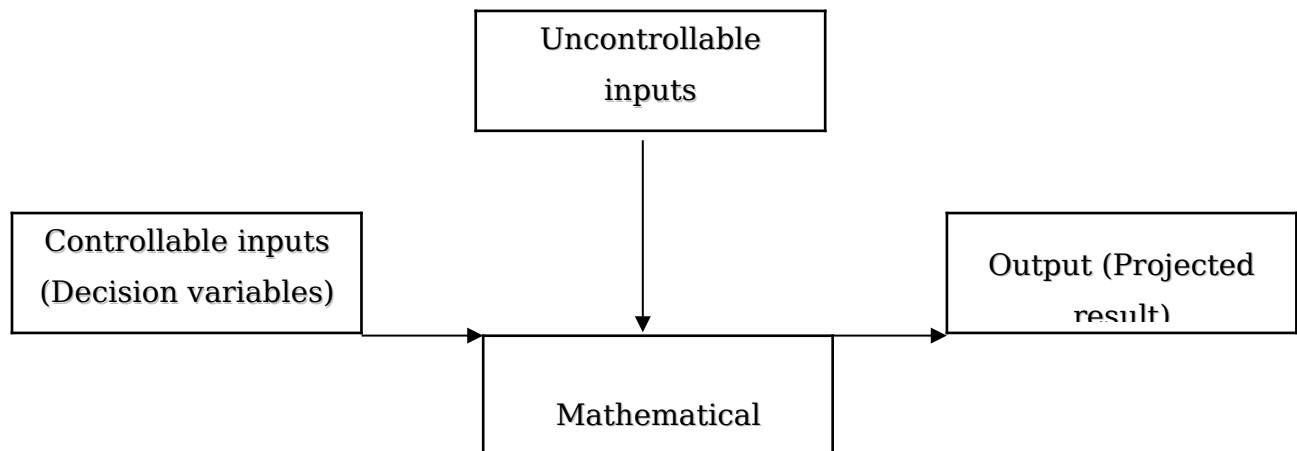
It represents unknown values of the problem. It is always expressed in terms of quantity, amount or number and is controllable by the decision maker.

2. Environmental elements (uncontrollable inputs)

Environmental factors that are not under the control of the manager or decision maker which can affect both the objective function and the constraints are referred to as the uncontrollable inputs to the model.

3. The decision (result) variable

Are controllable variables which are the decision alternative specified by the manager and thus are also referred to as the decision variable of the model. Decision variables are dependent of environmental parameters, because of this they are dependent variables. Once all the controllable and uncontrollable inputs are specified, the objective function and constraints can be evaluated and the output of the model determined. In this sense, the output of the model is simply the projection of what would happen if those particular environmental factors and decisions occurred in the real situation.



Flowchart of the process of transforming model inputs into output

The success of the mathematical model and quantitative approach will depend heavily upon how accurately the objective and constraints can be expressed in terms of mathematical equations or relationships.

Example: consider a mathematical model of linear programming model. This model assumes three basic parts.

- o Decision variables: they are unknowns of the problem which is expressed in terms of quantity, amount or number.
- o Objective function: it is a mathematical expression that describes the problem's objective.
- o The system constraints: limitations or restrictions imposed on the problem.

Illustration 1

Assume that Philips Corporation produces 2 types of TV sets called Model A and B. The company is in the market to make money; i.e., its objective is to maximize profit. The profit realized from set A and B respectively are Br. 300 and Br. 250.00. The corporation wants to produce and sell thousands of sets daily but this is not possible due to some limitations. These limitations are:

- There are only 40 hrs of labor each day in the production department (labor hr. constraint)
- There are only 45 hours of machine time each day.
- The maximum that can be sold off Model A TV sets are 12 (marketing constraints)

It is known that each set of Model A being higher in quality requires 2 hours of labor hr. and each set of Model B requires only 1 hr. of labor to be produced. The machine processing time for 1 unit of Model A and B are 1 hr and 3 hrs. respectively. If the company's objective is to maximize profit, how many sets of each model should be produced each day? Describe the situation with a mathematical model.

Solution

Given

	Labor hr.	Machine hr.	Marketing
	Contribution		per unit
			Constraint
Model A	2	1	≤ 12
Model B	1	3	
Resource Available			
Per day	40 hrs	45 hrs	

Formulation of the Model

Steps in formulation of the product mix problem:

Let :

- o x be the amount of Model A TV sets that will be produced and sold/day.
- o y be the number of Model B TV sets that will be produced and sold per day.
- o z be total profit
- o The objective function:
Total profit (Z) = $300x + 250y$
- o System constraints:
Labor hr constraint: $2x + y \leq 40$
Machine hr. constraint: $x + 3y \leq 45$
Marketing constraint: $x \leq 12$
Non negativity requirement: $x, y \geq 0$

Summary of the model:

Max z : $300x + 250y$

Subject to:

$$2x + y \leq 40$$

$$x + 3y \leq 45$$

$$x \leq 12$$

$$x, y \geq 0$$

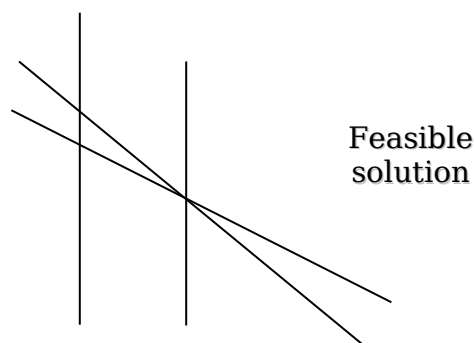
3. DATA PREPARATION

The third step in the process of quantitative analysis is the preparation of the data required by the model. Data in this sense refer to the values of the uncontrollable inputs to the model. All uncontrollable inputs or data must be specified before we can analyze the model and select a recommended decisions or solution for the problem.

In the above production model the values of uncontrollable inputs or data were \$300 and \$250 per unit for profit, 2 hrs and 1 hr per unit labor hour, 1 hr and 3 hrs per unit machine time, 40 hrs labor hour capacity, 45 machine hour capacity and 12 sets of Model A TV set requirement (marketing requirement). In the development of the model these data values were known and were incorporated into the model as it was being developed.

4. MODEL SOLUTION (SOLVING THE MODEL)

Once the model development and data preparation steps have been completed, we can proceed to the model solution step. In this step, the analyst will attempt to identify the values of the decision variables that provide the "best" output for the model. The specific decision variable value or values providing the best output will be referred to as **optimal solution** for the model. For the above production problem the model solution step involves finding the values of (the amount of model A and B TV sets) x & y that maximizes profit while not causing a violation of the system constraints.





- *It may be noted that the solution can be classified as feasible or infeasible, optimal or non-optimal, and unique or multiple optimal solutions.*

5. REPORT GENERATION AND IMPLEMENTATION

The final step in the quantitative analysis process is the preparation of managerial reports based upon the model's solution. Thus it is essential that the results of the model appear in a managerial report that can be easily understood by the decision maker. The report will include the recommended decision and other pertinent information about the model results that may be helpful to the decision maker. Although the generation of a managerial report is the final step in the quantitative analysis process, the implementation of the information contained in the report is a final action that remains to be taken by the manager or decision maker.

Successful implementation of results is of critical importance to the management scientists as well as the manager. If the results of the quantitative analysis process are not implemented, the entire effort may be of no value.

Check Your Progress Exercise

Part I: True/False With Justification

- _____ 1. Decision making is purely an art even in the modern age.
- _____ 2. Decisions taken only on the basis of quantitative analysis can be sound and correct.

- _____ 3. Operations research is inter-disciplinary in nature and requires a team approach to the solution in a problem.
- _____ 4. A feasible solution is one which satisfies all the constraints of the given problem, while an infeasible solution is one which satisfies none of them.
- _____ 5. As real life decision situations tend to be rather complex, the decision maker has to abstract from a given empirical situation those factors which are most relevant to the problem and combine them in some logical manner as to form a model of it.

Part II: Short Note

1. It is said that management is equivalent to decision making. Do you agree? Explain.

2. Discuss the role of OR/MS for decision making in business.

3. Operations research advocates a systems approach and is concerned with optimization. It provides a quantitative analysis for decision making. Comment on this.

1.7 SUMMARY

Management science is the discipline devoted to the solution of management problems using a scientific approach. The focus is on

problem solving using quantitative models. The approach is to define the problem, construct a model that reflects the important aspects of the problem, and analyze the model to identify an appropriate solution to the problem, implement the solution, and check to see that the problem has been solved.

The core of management science is the scientific approach to problem solving. An important part of this is the use of quantitative models. Models are abstractions of reality. Ideally, a model will capture the important aspects of a situation without including all of the minor details that would increase complexity and, there by, reduce the chances of finding a solution to the problem.

There are a variety of model types that are employed in decision making environments, management science models fall under the heading of symbolic models (that is, numbers and symbols are used to form mathematical models). Using these models, although in symbolic models the more important qualitative aspects of a problem may be ignored, Furthermore, quantitative models enable users to take advantage of the tremendous computational abilities of computers and calculators.

Management science has applications in forecasting, inventory management, production planning, capital budgeting, capacity planning, and other important areas of management decision making.

1.8 ANSWER TO CHECK YOUR PROGRESS EXERCISE

Part I

1. False
2. False
3. True
4. False

Part II

For more detail on this part refer to section 1.4 to

section 1.6

5. True