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Principles and Applications of Operations Research in Management Decision

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Introduction

OPERATIONS research (O.R.), a distinct discipline in its own right, has also become an integral part of many professions. This is hardly a matter of surprise when one considers that almost all professions believe in the principle and techniques of scientific management in problem-solving and decision-making in recent times. O.R. tries to avoid the danger of taking decisions merely by guessing by using thumb rules (Murthy, 1987). Operation research takes a quantitative and qualitative approach to management problems, which requires that decision problems be defined, analyzed and solved in a conscious, rational, logical, systematic and scientific manner- based on data, fact and information. Operation research is concerned with helping managers and executives to make better decisions; today's managers are working in a highly competitive and dynamic environment. In the present environment, the manager has to deal with systems, with complex interrelationships of various factors among them. As well as equally complicated dependence of the criteria of effective performance of the system on these factors, conventional methods of decision making are found very much inadequate (Murthy, 1987).

The quantitative approach does not preclude the qualitative or judgmental element that almost always exerts a substantial influence on managerial decision-making. This is quite the contrary. In actual practice, the quantitative approach must build upon, be modified by, and continually benefit from the experiences and creative insight of business managers. It makes modern managers to cultivate a managerial style that demands conscious, systematic and scientific analysis and resolution of problems. In a real-world problem, we can notice that a relationship exists among intuition, judgements, science, quantitation, attitudes, practices, methods and models as shown in Figure 1 below.

The above is corroborated by the statement of Michael and Camille (2000) that a combination of practical insight and technical skill is required in order to recognize which problem can be appropriately modelled in a linear programme format (i.e. mathematically) and then to formulate those problems accurately. This problem formulation, especially in business activities, must be cultivated through acquired knowledge of qualitative and quantitative techniques.

constant practice and experience. These views introduce us to some of the misconceptions that some professionals would like to correct, as explained later in this chapter.

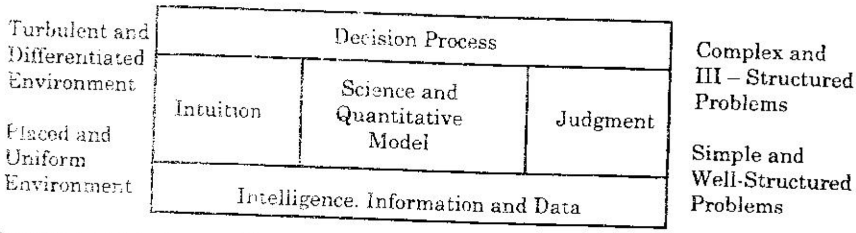


Fig. 1.1: Qualitative Thinking and Quantitative Models

Source: Murthy (1987)

A Historical Perspective

While there is no clear date that marks the birth of O.R., some say that Charles Babbage (1791-1871) is the "father of operations research" because his research into the cost of transportation and sorting of mails led to England's universal "Penny Post" in 1840, and studies into the dynamic behaviour of railway vehicles in defence of the GWR's broad gauge. The modern field of operations research arose during World War II. Scientists in the United Kingdom including A.P. Rowe, Patrick Blackett, Cecil Gordon, C. H. Waddington, Owen Wansbrough-Jone and Frank Yates, and in the United State with George Dantzig looked for ways to make better decisions in such areas as logistics and training schedules. After the war, some individuals began to apply it to similar problems in industries (Wikipedia –Encyclopedia, 2009).

The modern field of O.R. as a formal subject is over fifty years old and it may be traced to World War II. Most of the O.R. techniques that are commonly used today were developed over (approximately) the first twenty years following its inception. During the last thirty years, the pace of development of fundamentally new O.R methodologies has slowed somewhat. However, there has been a rapid expansion in: (1) the breadth of problem areas to which O.R. has been applied, and (2) the magnitudes of the problems that can be addressed using O.R. Methodologies (Rajgopal. 2004). The impetus for its origin was the development of radar defense systems for the Royal Air Force, and the first recorded use of the term operations research is attributed to a British Air Ministry official named A. P. Rowe, who constituted teams to do "operational researches" on the communication system and the control room at a British radar station. The studies had to do with improving the operational efficiency of systems (an objective which is still one of the cornerstones of modern O.R.). This new approach of picking an "operational" system and conducting "research" on how to make it run more efficiently soon started to expand into other arenas of the war. Perhaps the most famous of the groups involved in this effort was the one led by a physicist named P. M. S. Blackett, which included physiologists, mathematicians, astrophysicists, and even a surveyor. This multifunctional team focus of an operations research project group is one that still exists to this day. Blackett's biggest contribution was in convincing the authorities of the need for a scientific approach to manage complex operations, and indeed he is regarded in many circles as the original operations research analyst (Rajgopal, 2004).

Blackett's team undertook a number of crucial analyzes that aided the war effort. Britain introduced the convoy system to reduce shipping losses, but while the principle of using warships to accompany merchant ships was generally accepted, it was unclear whether it was better for convoys to be small or large. Convoys travel at the speed of the slowest member, and small convoys can travel faster. It was also argued that small convoys would be harder for German U-boats to detect. On the other hand, large convoys could deploy more warships against an attacker. Blackett's staff showed that the losses suffered by convoys depended largely on the number of escort vessels present, rather than on the overall size of the convoy. Their conclusion, therefore, was that a few large convoys were more defensible than many small ones.

In another piece of work, Blackett's team analyzed a report of a survey carried out by RAF Bomber Command. For the survey, Bomber Command inspected all bombers returning from bombing raids over Germany over a particular period. All damage inflicted by German air defenses was noted and the recommendation was given that armour should be added in the most heavily damaged areas. Their suggestion to remove some of the crew so that an aircraft loss would result in fewer personnel loss was rejected by RAF Command. Blackett's team instead made the surprising and counter-intuitive recommendation that the armour be placed in the areas which were completely untouched by damage, in the bombers which returned – they reasoned that the survey was biased, since it only included aircraft that returned to Britain. The untouched areas of returning aircraft probably vital areas, which, if hit, would result in the loss of the aircraft (Wikipedia-Encyclopedia, 2009).

O.R. made its way to the United States a few years after it originated in England. Its first presence in the U.S. was through the U.S. Navy's Mine Warfare Operations Research Group. This eventually expanded into the Antisubmarine Warfare Operations Research Group that was led by Phillip Morse, which later became known simply as the Operations Research Group. Like Blackett in Britain, Morse is widely regarded as the "Father" in the United States, and many of the distinguished scientists and mathematicians that he led went on after the end of the war to become the pioneers of O.R. in the United States (Rajgopal, 2004).

In the years immediately following the end of World War II, O.R. grew rapidly as many scientists realized that the principles that they had applied to solve problems for the military were equally applicable to many problems in the civilian sector. "These ranged from short-term problems such as scheduling and inventory control to long-term problems such as strategic planning and resource allocation. George Dantzig, who in 1947 developed the simplex algorithm for Linear Programming (LP), provided the most important impetus for this growth. To this day, LP remains one of the most widely used of all O.R. techniques and despite the relatively recent development of interior point methods as an alternative approach, the simplex algorithm (with numerous computational refinements) continues to be widely used. The second major impetus for the growth of O.R. was the rapid development of digital computers over the next three decades. The simple method was implemented on a computer for the first time in 1950, and by 1960 such implementations could solve problems with about 1,000 constraints. Today, implementations on powerful workstations can routinely solve problems with hundreds of thousands of variables and constraints. Moreover, the large volumes of data required for such problems can be stored and manipulated very efficiently (Rajgopal, 2004).

Once the simplest method had been invented and used, the development of other methods followed at a rapid pace. The next twenty years witnessed the development of most of the O.R. techniques that are in use today including nonlinear, integer and dynamic programming, computer simulation, PERT/CPM, queuing theory, inventory models, game theory, and sequencing and scheduling algorithms. The scientists who developed these methods came from many fields, most notably mathematics, engineering and economics. It is interesting that the theoretical bases for many of these techniques had been known for years, e.g., the EOQ formula used with many inventory models was developed in 1915 by Harris, and many of the queuing formulae were developed by Erlang in 1917. However, the period from 1950 to 1970 was when these were formally unified into what is considered the standard tool kit for an operations research analyst and successfully applied to problems of industrial significance. The following section describes the approach taken by operations research in order to solve problems and explores how all of these methodologies fit into the O.R. framework (Rajgopal, 2004).

Theoretical Framework

The Concept and Nature of Operations Research

The odd against the definition of O.R. is the common misconception held by many that O.R. is a collection of mathematical tools. While it is true that it uses a variety of mathematical techniques, operations research has a much broader scope, as there is more to problem solving, especially in management decisions, than the construction and solution of mathematical models. It is in fact a systematic approach to solving problems, which uses one or more analytical tools in the process of analysis (Rajgopal, 2004). Specifically, decision problems usually include important intangible factors that cannot be translated directly in terms of the mathematical model.

Foremost among these factors is the presence of the human element in almost every decision environment. Indeed, decision situations have been reported where the effect on human behaviour has so influenced the decision problem that the solution obtained from the mathematical model is deemed impractical. A good illustration of these cases is of the widely circulated *elevator problem*. In response to tenants' complaints about slow elevator service in a large office building, a solution based on analysis by waiting line theory was found unsatisfactory. After studying the system further, it was discovered that the tenant complaints were more a case of boredom, since in reality the actual waiting time was quite short. A solution was proposed whereby full length mirrors were installed at the entrances of the elevators. The complaints disappeared because the elevator users were kept occupied watching themselves and others while waiting for the elevator service (Taha, 1987).

The above illustration underscores the importance of viewing the mathematical aspect of operations research in the wider context of decision making processes whose elements cannot be represented totally by a mathematical model. Indeed this point was recognized by British scientists who pioneered the first O.R. activities during World War II. Although their work was concerned primarily with the optimum allocation of the limited resources of war materials, the team included scientists from such fields as sociology, psychology and behavioral science in recognition of the importance of their contribution in considering the intangible factors of the decision processes.

As a problem-solving technique, O.R. must be viewed as both science and art. The science aspect lies in providing mathematical techniques and algorithms for solving appropriate decision problems. Operation research is an art because all the phases that proceed or succeed the solution of a mathematical model largely depend on the creativity and personal ability of the decision making analysts. Thus, gathering the data for model construction, validation of the model, and implementation of the obtained solution will depend on the ability of the O.R. team to establish a good line of communication with the sources of information as well as with the individuals responsible for implementing recommended solutions (Taha, 1982).

The above illustration explains why professions (course) that acquire knowledge in social science, management, economics and engineering science like industrial engineering, system engineering, management technology (technology management) and management sciences can easily view both the art and the science part of O.R. while mathematicians and statisticians alike continue in their misconception about the discipline of O.R. To them operation research refers to a quantitative techniques/mathematical methods or mathematical techniques (Murthy, 1987). Hence, some of their definitions of O.R. are as follows:

- A branch of mathematics – specially applied mathematics used to provide a scientific tease for management to take timely and effective decisions on their problems (Murthy, 1987)
- Operational research is the attack of modern science on complex problems arising in the direction and management of large systems of men, machines, materials and money in industry, business, government and defense (Operational Research Society of Great Britain, 2009).
- Mathematical or scientific analysis of a process or operation, used in making decisions
- Operations research is a scientific approach to problem-solving for executive management (Wagner, 2001).

Although Rajgopal believes that the name O.R. does not conjure up any sort of meaningful image, this is not true if the two words in the term are examined:

Operation: This can be viewed as the organized activit(ies) or task(s) that achieve (s) achieve some set objectives in that system.

Research: This is a process of seeking solution to a problem (Nworuh, 2004); seeking or searching deeply into something for the purpose of getting more information about it (Nworuh, 2004); is finding out ways of solving a problem. Since there are both quantitative and qualitative methods of searching for information to solve problems, we can discard the view that O.R. is a mere quantitative/mathematical technique or mathematical method. We can then and see the discipline in light of what it is – as an art and a science. While mathematics and mathematical models represent the scientific aspect of O.R., an acquired knowledge in social sciences, i.e. psychology, judgment and reasoning represent the art part.

Regardless of the exact words used, it is probably safe to say that the moniker "operations research" is here to stay and it is therefore important to understand that in essence, O.R. may simply be viewed as *a systematic and analytical approach to decision-making and* problem-solving. The key here is that O.R. uses a methodology that is objective and clearly articulated, and is built around the philosophy that such an approach is superior to one that is based purely on subjectivity and the opinion of "experts," in that, it will lead to better and more consistent decisions (Rajgopal, 2004). In view of the above illustrations, we can then say that operations research can be viewed as seeking the determination of the best (optimum) course of action of a decision problem under the restriction of limited resources (Taha, 1982).

Operations Research

Operations research can be viewed as the use of systematic and analytical methods to seek determination of the best (optimum) course of action (decision) of a decision problem (i.e. among alternative courses of action) under the restriction of limited resources. This shows that O.R. does and cannot preclude the use of human judgment or non-quantifiable reasoning; rather, the latter are viewed as being complementary to the analytical approach. One should thus view O.R. not as an absolute decision-making process, but as an *aid* to making good decisions. O R. plays an advisory role by presenting a manager or a decision-maker with a set of sound, systematic and analytically derived alternatives. The final decision is always that of the human being who has knowledge that cannot be exactly quantified, and who can temper the results of the analysis to arrive at a sensible decision. This shows the importance of the art part of O.R.

Conceptual Framework

It is important to have a detailed understanding of the .framework o O.R. so that it is effectively used to take the optimum management decision when applied to a generic problem. To achieve this, we would look at some O.R. *approaches*. Although there is no generally acceptable step/approach, as different authors adopt different approaches that they believe are most appropriate to them, considerable level of similarity can be observed among them. Some of them are as shown in Figures (2.5) below. After a careful observation of Figure (2.5), we developed the approach in figure 6 below. We thus applied this approach to two scenarios to relate it to management decision-making.

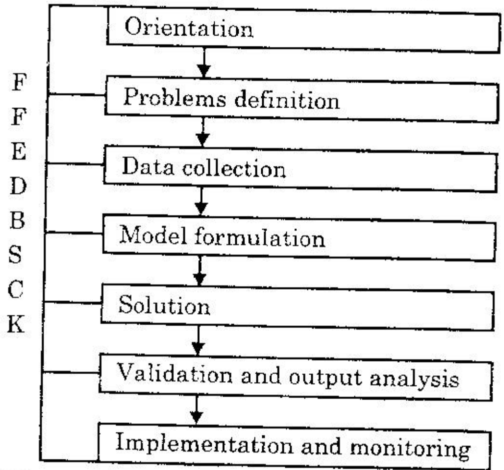


Fig. 2: Operations Research Approach

Source: *Rajgopal (2004).*

Model: SM-14	
Stage 1 -	Curious observation
Stage 2 -	Is there a problem?
Stage 3 -	Goals and planning
Stage 4 -	Search, explore, and gather the evidence
Stage 5 -	Generate creative and logical solutions
Stage 6 -	Evaluate the evidence
Stage 7 -	Make the educated guess (hypothesis)
Stage 8 -	Challenge the hypothesis
Stage 9 -	Reach a conclusion
Stage 10 -	Suspend judgment
Stage 11 -	Take action
Supporting Ingredients	
Stage 12 -	Creative, non-logical, logical, and technical methods for decisions
Stage 13 -	Procedural principles and theories for decisions
Stage 14 -	Attributes and thinking skills for decisions

Fig. 3: Strategic Decision Making

Source: *Edmund (2008)*

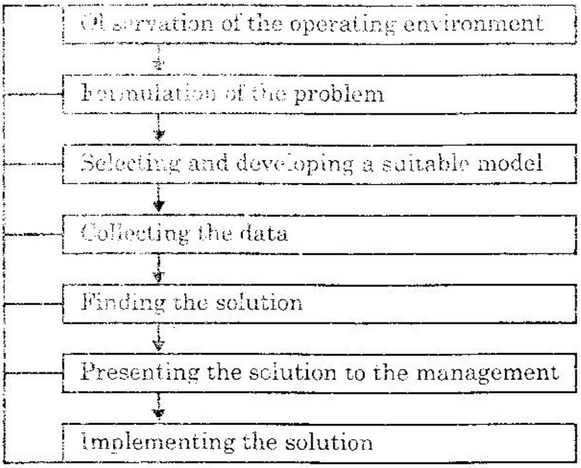
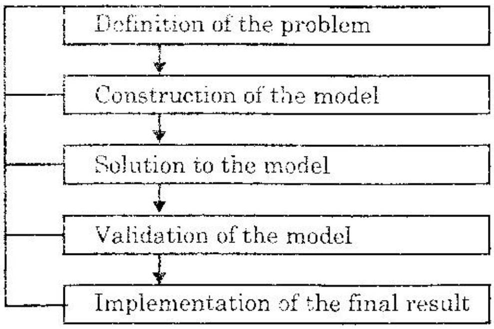


Fig. 4: O.R. Approach
Source: Cheema (2005).



Source: *Taha (1982).*
Fig. 5: O.R. Approach

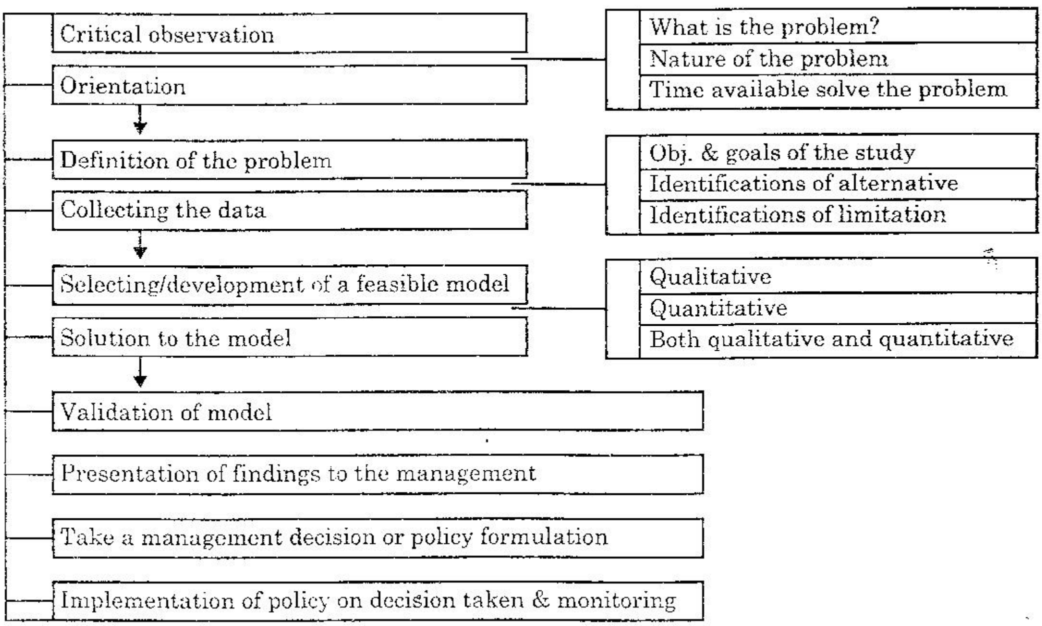


Fig. 6: The newly developed phases of O.R. Model
Source: *Author's design*

The two scenarios were the elevation problem mentioned earlier and a manufacturing company planning its production mix for the next period. The company makes use of two basic raw materials and produces two types of products which compete for these resources. The products have differing profit margins and require different amounts of each resource. The resources are limited in their availability. Additionally, there are other complicating factors such as uncertainty in the demand for the products, etc. Given this complex operating environment, the overall objective is to plan next period production so that the company can realize the maximum profit possible while simultaneously ending up in a good position for the following period(s).

An illustration of how one might conduct an operations research study to address scenarios can now be considered using the approach in Figure 6. Note that in the second scenario each product requires varying amounts of each of the two resources in making the products and realizes different revenues when the objective of the O.R. project is to allocate the resources to the two products in fashion.

Critical observation: Albert Einstein said, "I have no special gift, I am only pass curious" and "The formulation of a problem in management is far more often than its solution." A solution may be a result of mere skill, while the discovery of a problem or decision requires an inquisitive, curious mind (Edmund, 2008). This is the first step in the O.R. approach. It involves the determination of:

(a) *What the problem is:* i.e. determine by critically examining the system if there is a problem. In the two scenarios, the customers complain and the inabilities of the second organization to know an appropriate allocation of resources that will maximize profit constitute the problem in each case. Sometimes, a more critical observation would lead to the discovery of more information about the problems.

(b) *The nature of the problem:* If the nature of the problem is known, it will make it easy for the O.R. analyst to know whether a qualitative approach should be applied as in the elevation problem or a quantitative approach or both as in the product mix problem.

(c) *The time available to solve the problem:* In management, it has been observed that so many decisions are taken daily in an operating environment. And, though the use of computer has reduced the processing time of solving a mathematical model, the time to determine which computer software will solve effectively a newly developed model could prevent the use of quantitative techniques sometimes even when it is the most appropriate due to the non-availability of time.

Note that the complete method of creative problem-solving and decision making depends on people using curious observation to find problems that need to be solved and decisions that need to be made. Curiosity is a personal attribute that if continually exercised, will improve your creativity and keep you ahead of the competition and successful in all phases of life, especially in management decision-making. Curiosity, when carried through all the stages of the complete method of creative decision-making results in better judgment and an improved management decision-making.

Orientation: The second step in the O.R. approach is described as problem orientation. The primary objective of this step is to constitute the team that will address the problem at hand and ensure that all its members have a clear picture of the relevant issues. It is worth noting that a distinguishing characteristic of any O.R. Study is that it is done by a multifunctional team (Rajgopal, 2004). In the elevation problem, the mathematical model formulated was found to be unsatisfactory, but the inclusion of a psychologist in the O.R. team created the solution to the problem by development of a qualitative model of the system. It will also be inappropriate to develop any kind of model without an input from production personnel, sales personnel, purchase personnel etc.

Typically, the team will have a leader and be constituted of members from various functional areas or departments that will be affected by or have an effect upon the problem at hand. In the orientation phase, the team typically meets several times to discuss all of the issues involved and to arrive at a focus on the critical ones. This phase also involves a study of documents and literature relevant to the problem in order determine if others have encountered the same (or similar) problem in the past, and if so, to determine and evaluate what was done to address the problem (Rajgopal, 2004). It should be noted that a critical observation of the system will help in identifying the relevant personnel that should be part of the team.

Problem Definition: This is the third and in most cases in management decision problems a crucial part of the OR process. The objective here is to further refine the critical observations cited in the first phase, since there could be further contributions of inputs from members of the team to get three major aspects. These are:

(i) *Detailed and unambiguous objectives/goals and the variables that describe the system:* In the elevation problem, the objective is to eliminate the boredom, since an acceptable waiting time has been achieved. The identification of relevant variables (which depends on the bias and training of the decision maker) by a member of the team trained in psychology and human behaviour helps in stating these objectives. In the production mix, the objective could be to minimize the cost of resource allocation. The controllable variables (the amount of each resources, that is allocated to each product, i.e. can be controlled by the decision maker) and uncontrollable variables (the change in competition prices on the analysis) identified by expert help to determine an acceptable goal for the system.

(ii) *The alternative course of action:* From the concept of O.R. stated above it should be noted that O.R. rarely developed a solution directly to a problem. It identifies the optimum (best) solution among existing alternative solutions, hence the phrase "decision problem" (that is, the numerous solutions have constituted themselves to be a problem to the decision maker). Thus, once there is only one solution to a problem, then an O.R. analysis is not needed. In the elevation problem, the construction of more lift is an alternative, while in the production mix, the various degree of allocation of each resource to the production of two products shows the enormous amount of alternatives available.

(iii) *Identification of the limitations, restrictions and requirements of the system:* 'This is a very important part of problem definition. It helps to eliminate ambiguous objectives, i.e. allocation of more resources to one of the products without due consideration of its contribution to revenue or the maximum demand of the product in the market or the maximum availability of the resources in the production mix problem. It also concerns the maximum amount that can be spent or space available in the building as with the elevation problem.

Data Collection: In the fourth phase of the O.R. process, data is collected with the objective of translating the problem defined in the third phase into a model that can then be both subjectively and objectively analyzed. Data collection started from the first phase of the process of critical observation of the system. This continues as members of the team contribute inputs that suggest the relevant areas to draw data from and the identification of both the controllable and uncontrollable variables that need to be measured or obtained by any other methods. Other data are obtained by using standards; a lot of cost-related information tends to fall into this category. For instance, companies have standard values for cost items such as hourly wage rates, inventory holding charges, selling prices, etc. These standards must then be consolidated appropriately to compute costs of various activities. On occasion, data may also be solicited expressly for the problem at hand through the use of surveys, questionnaires or other psychometric instruments (Rajgopal, 2004). Data collection can have an important effect on the previous step of problem definition as well as on the following step of model formulation.

Model Formulation: This is the fifth phase of O.R. and deals with model of construction. The misconception about O.R. and why so many business managers feel that it is full of sets impracticable analyses are due to this phase. Depending on the definition of the problem, the O.R. team should decide on the most suitable model to represent the system. To many, the word model connotes a mathematical expression of the system. It should be emphasized here that there are both quantitative models and qualitative models. The causal loop diagram used in the system dynamic is a schematic model that is not mathematical. In the formation of a model in O.R., the analyst should first determine the type of model that will be appropriate, i.e. a quantitative model, as used in production mix problems or a qualitative model as used in decision making problems similar to the elevation problem or both as in system dynamics. Thus, there is no single "correct" way to build a model and, as often noted model building is more an art than a science. A model may be defined formally as a selective abstraction or duplication of reality.

This definition implies that modeling is the process of capturing selected characteristics of a system or a process and then combining these into an abstract representation of the original. The main idea here is that it is usually far easier to analyze a simplified model than it is to analyze the original system, and as long as the model is a reasonably accurate representation, conclusions drawn from such an analysis may be validly extrapolated back to the original system (Rajgopal, 2004).

Solution: The sixth phase of the O.R. process is the solution of the problem represented by the model. This is the area on which a huge amount of research and development in O.R. has been focused, and there is a plethora of methods for analyzing a wide range of models (Rajgopal, 2004). It is impossible to get into details of these various techniques in a single introductory chapter such as this. Generally speaking, the techniques used here depend on the type of model developed. If a schematic diagram is used to represent the system under investigation then a systematic and logical examination of the system or other qualitative techniques are used to determine the best course of action. In mathematical models, as in the production mix problem, a well-defined optimization technique could yield an optimum solution. But in complex situations where simulation or heuristic models are used, the concept of optimality is not well defined and the solutions in these cases are used to obtain approximate evaluations of the measures of the system (Taha, 1982).

Depending on the model developed, there are so many other techniques – qualitative and quantitative –that have been developed to find solutions to O.R. models. Some formal training in operations research is necessary in order to appreciate how many of these methods work and the interested reader is urged to peruse introductory texts on O.R. which are suggested in the section on "Further Reading" at the end of this chapter.

Validation and Analysis: In this seventh phase, the process of ensuring that the model is an accurate representation of the system is called validation and this is something that (whenever possible) should be done before a management decision or policy is formulates from the output of an O.R model solution. A model is valid if, despite its inexactness in representing the system, it can give a reasonable prediction of the system's performance. A common method for testing the validity of a model is to compare its performance with some past data available for the actual system. The model will be valid if under similar conditions of inputs, it can reproduce the past performance of the system. The problem here is that there is no assurance that future performance will continue to duplicate past history. Also, since the model is based on careful examination of past data, the comparison should always reveal favourable results. In some instances, this problem may be overcome by using data from trial runs of the system (Taha, 1982).

It must be noted that such a validation method is not appropriate for non-existing systems, since data will not be available for comparison. In some cases, if the original system is investigated by a mathematical model, it may be feasible to construct a simulation model from which data are obtained to carry out the comparison. However, it is sometimes necessary to solve the model in order to discover inaccuracies in it. A typical error that might be discovered at this stage is that some important constraint was ignored in the model formulation; this will lead to a solution that is clearly recognized as being infeasible and the analyst must then go back and modify the model and re-solve it. This cycle continues until one is sure that the results are sensible and come from a valid system representation (Taha, 1982).

Presentation of Findings to Management: This is the eighth (8th) phase of O.R. process in management decision. Most managers are not interested in the models or solutions that were formulated about the problem at hand. Thus, the only way to communicate with them is the presentation of the O.R. team's proposed advice based on their (O.R. Team) result. Good communication skills in technical report writing for managers are thus necessary for this purpose. This would involve the translation of these results into detailed operating instructions issued in an understandable form to individuals who will either finance or approve the implementation of the result. If not, the entire project will seem impracticable. But when the resources for the implementation of the result is readily at the disposal of the O.R. team, then this phase might not be necessary but could be used to develop a record that can be referred to later.

Taking a Management Decision or Policy Formulation: Based on the presentation of the last phase (phase eight above), a management decision can easily be taken for implementation purposes, or a policy that can guide possible cause of action when similar situations occur can be formulated. Even with the extensive use of computer programmes (software), real-life situations will still demand a creative policy that can be generated from this phase for proper implementation and monitoring.

Implementation and Monitoring: The final phase of the study deals with the implementation of the policies formulated. The burden of executing these results primarily with the operations researchers. This would also involve translating the results into detailed operating instructions issued in an understandable form to the individuals who will administer and operate the recommended system. Interaction between the operations research team and the operating personnel will reach this phase. Communication between the two groups can be improved by seeking the participation of the operating personnel in developing the implementation plan. In fact, this participation should be sought throughout all phases of the study. In this way, no practical consideration that might lead to system failure will be overlooked. Meanwhile, possible modifications or adjustments in the system may be checked for feasibility by the operating personnel. In order words, it is imperative that the implementation phase be executed through the cooperation of both the operations research team and those who will be responsible for managing and operating the system. Once implementation is complete, responsibility for monitoring the system is usually turned over to an operating team.

From an O.R. perspective, the primary responsibility of the latter is to recognize that the implemented results are valid only as long as the operating environment is unchanged and the assumptions made by the study remain valid.

Conclusion

This chapter provides an overview of operations research, its origins and its approach to solving problems, in management. From the standpoint of management technologists, O.R. is a tool that can do a great deal to improve productivity. It should be emphasized that O.R is neither esoteric nor impractical, and the interested professional or academic is urged to study,this topic further for its techniques as well as its applications; the potential rewards can be enormous.

Multiple Choice Questions

(1) Operations research is a collection of mathematical tools only. True /False

(2) Operations research is a problem-solving technique viewed as ____________
(a) systematic only (b) analytical only (c) both systematic and analytical
(d) systematic and scientific

(3) __________ is viewed as the organized activity(ies) or task(s) that is/are performed to achieve some set of objectives. (a) Operations research (b) Research (c) Operation (d) Management.

(4) Operations research uses an objective and articulate ____________
(a) methodology (b) theory ('c) law (d) model

(5) Operations research is not a/an __________ (a) Absolute decision making process (b) aid to making good decision (c) provider of systematic and analytical (d) none of the above.

(6) Problem-solving and decision making depends on _________ using curious observation to find out problem that need to be solved (a) people (b) methodology (c) computer software (d) environment.

(7) The primary objective of orientation in operation research is _________
(a) to constitute the team that will solve problem at hand and ensure that all its members have a clear picture of the relevant (b) to find problems that need to be solved (c) to make decisions and provide solutions (d) to develop models

(8) Which is not a characteristic of operations research? (a) It is done by a multifunctional team (b) It uses computer extensively (c) Model construction
(d) Absolute decision making process.

(9) ___________ is regarded as the father of Operations Research in the United States.
(a) Blackett (b) Morse (c) Rajgopal (d) Taha

(10) ___________ is regarded as the father of Operations Research in Britain.
(a) Blackett (b) Morse (c) Rajgopal (d) Taha

(11) The objective of ___________ is to further refine the critical objectives.
(a) data collection (b) model formulation (c) problem definition (d) critical observation

(12) Operations Research rarely develops a solution directly to a problem. True/ False

(13) When there is only one solution to a problem, an Operations Research analysis is not needed. True/False

(14) It is the objective of _____ to translate a problem defined in problem definition into a model that can be subjectively and objectively analyzed. (a) mode formulation
(b) data collection (c) orientation (d) validation and analysis

(15) Modes building is more an art than a science. True/False

(16) The phase of Operations Research approach in which research and development has been focused is _________ (a) validation and analysis (b) model formulation
(c) data (d) solution.

(17) If a schematic diagram is used to represent the system under investigation, then a ___________ is not used to determine the best course of action. (a) quantitative technique (b) qualitative tecnnique (c) systematic examination (d) logical examination.

(18) The process of ensuring that the mode is an accurate representation of the system is called ________ (a) model formulation (b) solution (c) validation (d) critical observation.

(19) A model is not valid if it cannot provide a reasonable prediction of the system's performance. True /false

(20) A method for testing the validity of a model are to compare its performance with ___________ (a) past data (b) future (c) calculated data (d) randomly selected data

(21) Presentation of findings to management involves the translation of results into detailed ___________ issued in an understandable form. (a) operating instruction (b) system (c) communication (d) outcome

(22) When the resources that are important for the result are readily at the disposal of the operators, then presentation of findings to management might not be necessary. True /False.

(23) Which of the following does not involve the translation of results into detailed operating instructions in an understandable form? (a) Presentation of findings to management (b) Implementation and monitoring (c) Policy formulation
(d) None of the above

(24) In what phase will the interaction between the operations research team and the operating personnel reach its peak? (a) Implementation and monitoring (b) Policy formulation (c) Presentation of findings to management (d) orientation.

Theory Questions

(1) What is Operations Research and why is it used by managers today?
(2) Give a brief history of Operations research.
(3) What are decision problems?
(4) Operations research is viewed as both an art and a science. Explain
(5) Explain the steps involved in Operations Research approaches.

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