The Introductory Study of Operations Research & Its Applications

Pankaj Patel

Research Scholar, Singhania University, Rajasthan

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INTRODUCTION

The term 'Operations Research' (OR) describes the discipline that is focused on the application of information technology for informed decision-making. In other words, OR represents the study of optimal resource allocation. The goal of OR is to provide rational bases for decision making by seeking to understand and structure complex situations, and to utilize this understanding to predict system behavior and improve system performance. Much of the actual work is conducted by using analytical and numerical techniques to develop and manipulate mathematical models of organizational systems that are composed of people, machines, and procedures. This article introduces some of the methods and application that are affiliated with OR, and elaborates on some of the benefits that may be gained by incorporating OR into the actual business framework.

ROLE OF OR

OR's role in both, the public and the private sectors is increasing rapidly. In general, OR addresses a wide variety of issues in transportation, inventory planning, production planning, communication operations, computer operations, financial assets, risk management, revenue management, and many other fields where improving business productivity is paramount. In the public sector, OR studies may focus on energy policy, defense, health care, water resource planning, design and operation of urban emergency systems, or criminal justice. To reiterate, OR reflects an analytical method of problem solving and decision-making that is useful in the management of organizations. In OR, problems are (1) decomposed into basic components and (2) solved via mathematical analysis. Some of the analytical methods used in OR include mathematical logic, simulation, network analysis, queuing theory, and game theory. The actual OR process can in general be described via three steps. (1) A set of potential solutions to a problem is identified and developed (the set may be rather large). (2) The alternatives derived in the first step are analyzed, and reduced to a smaller set of solutions (the solutions have to be feasible and workable). (3) The alternatives derived in the second step are subjected to simulated implementation and, if feasible, exposed to an actual analysis in a real-world environment. It has to be pointed out that in the final step, psychology and management sciences often play a rather important role. Generally speaking, OR improves the effectiveness and the efficiency of an institution, hence some of the benefits offered by OR include:

- Decrease Cost or Investment
- Increase Revenue or Return on Investment
- Increase Market Share
- Manage and Reduce Risk
- Improve Quality
- Increase Throughput while Decreasing Delays
- Achieve Improved Utilization form Limited Resources
- Demonstrate Feasibility and Workability

OR FUNCTIONS AND METHODS

OR may assist decision-makers in almost any management function. To illustrate, OR supports the key decision making process, allows to solve urgent problems, can be utilized to design improved multi- step operations (processes), setup policies, supports the planning and forecasting steps, and measures actual results. OR can be applied at the non-manager levels as well, as engineers or consumers alike can benefit from the improved and streamlined decision-making process.

When first encountered, the methods commonly utilized in OR may seem obscure. Technical labels such as multi-criteria decision analysis, linear and non-linear and non programming discrete-event simulation, queuing and stochastic process modeling, conjoint analysis, or neural networking further foster this general impression. Despite the wealth of labels available in the filed of OR, most projects apply one of three broad groups of methods, which may be described as:

- Simulation methods, where the goal is to develop simulators that provide the decision-maker with the ability to conduct sensitivity studies to (1) search for improvements, and (2) to test and benchmark the improvement ideas that are being made.

- Optimization methods, where the goal is to enable the decision maker to search among possible choices in an efficient and effective manner, in environments where thousands or millions of choices may actually be feasible, or where some of the comparing choices are rather complex. The ultimate goal is to identify and locate the very best choice based on certain criteria's.

- Data-analysis methods, where the goal is to aid the decision-maker in detecting actual patterns and inter-connections in the data set. This method is rather useful in numerous applications including forecasting and data mining based business environments.

Within each of the three basic groups, many probabilistic methods provide the ability to assess risk and uncertainty factors.

OR IN MANUFACTURING

As OR has made (over the years) significant contributions in virtually all industries, in almost all managerial and decision-making functions, and at most organizational levels, the list of OR applications is prodigious. Hence, this article focuses in the next few paragraphs on the manufacturing industry, and introduces some of the application where OR is being used.

The term operations in OR may suggests that the manufacturing application category represents the original home of OR. That is not quite accurate, as the name originated from military operations, not business operations. Nevertheless, it is a true statement that OR's successes in contemporary business pervade manufacturing and service operations, logistics, distribution, transportation, and telecommunication. The myriad applications include scheduling, routing, workflow improvements, elimination of bottlenecks, inventory control, business process re-engineering, site selection, or facility and general operational planning. Revenue and supply chain management reflect two growing applications that are distinguished by their use of several OR methods to cover several functions. Revenue management entails first to accurately forecasting the demand, and secondly to adjust the price structure over time to more profitably allocate fixed capacity. Supply chain decisions describe the who, what, when, and where abstractions from purchasing and transporting raw materials and parts, through manufacturing actual products and goods, and finally distributing and delivering the items to the customers. The prime management goal here may be to reduce overall cost while processing customer orders more efficiently than before. The power of utilizing OR methods allows examining this rather complex and convoluted chain in a comprehensive manner, and to search among a vast number of combinations for the resource optimization and allocation strategy that seem most effective, and hence beneficial to the operation.

PRODUCTION SYSTEM

Businesses and organizations frequently face challenging operational problems whose successful solution requires certain expertise in applied statistics, optimization, stochastic modeling, or a combination of these areas. To illustrate, a company may need to design a sampling plan in order to meet specific quality control objectives. In a manufacturing environment, operations that compete for the same resources must be scheduled in a way that deadlines are not violated. The manager of a supermarket must determine how many checkout lines to keep open at various times during the day and evening so that shoppers are not unnecessarily delayed. Or as a final example, the size of the areas reserved for storing work in process at a number of bottleneck stations has to be determined so that a smooth flow of work results, even at the busiest (peak) production times.

The area of operations research that concentrates on real-world operational problems is called production systems. Production systems problems may arise in settings that include, but are not limited to, manufacturing, telecommunications, health-care delivery, facility location and layout, and staffing. The area of production systems presents special challenges for operations researchers. Production problems are operations research problems, hence solving them requires a solid foundation in operations research fundamentals. Additionally, the solution of production systems problems frequently draws on expertise in more than one of the primary areas of operations research, implying that the successful production researcher cannot be one-dimensional. Furthermore, production systems problems cannot be solved without an in-depth understanding of the real

problem, since invoking assumptions that simplify the mathematical structure of the problem may lead to an elegant solution for the wrong problem. Common sense and practical insight are common attributes of successful production planners. At the current time, the filed of OR is extremely dynamic and ever evolving. To name a few of the contemporary (primary) research projects, current work in OR seeks to develop software for material flow analysis and design of flexible manufacturing facilities using pattern recognition and graph theory algorithms. Further, approaches for the design of re-configurable manufacturing systems and progressive automation of discrete manufacturing systems are under development. Additional OR projects focus on the industrial deployment of computer-based methods for assembly line balancing, business process reengineering, capacity planning, pull scheduling, and setup reduction, primarily through the integration of the philosophies of the Theory of Constraints and Lean Manufacturing. Please see Appendix A for a short introduction to the objectives and key principles of the Lean Manufacturing principles).

SUMMARY

The driving idea behind OR is to collaborate with clients to design and improve operations, make better decisions, solve problems, and advance managerial functions including policy formulation, planning, forecasting, and performance measurement. 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.

Lean Manufacturing reflects a set of tools and methodologies that aims at the continuous elimination of all waste in the production process. The main benefits are (1) lower production costs, (2) increased output and (3) shorter production lead times. More specifically, some of the major goals are:

- Defects and wastage - Reduce defects and unnecessary physical wastage, including excess use of raw material (inputs), preventable defects, costs associated with reprocessing defective items, and unnecessary product characteristics which are not required by customers.

- Cycle Times - Reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages, as well as process preparation times and product/model conversion times.

- Inventory levels - Minimize inventory levels at all stages of production, particularly works-in-progress between production stages. Lower inventories also imply lower working capital requirements.

- Labor productivity - Improve labor productivity, both by reducing the idle time of workers and ensuring that when workers are working, they are using their effort as productively as possible.

- Utilization of equipment and space - Use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production though existing equipment, while minimizing machine downtime.

- Flexibility - Have the ability to produce a more flexible range of products with minimum changeover costs and changeover time.

- Output – In regards to reduced cycle times, increased labor productivity and elimination of bottlenecks and machine downtime can be achieved, companies can generally increase the output from their existing facilities.

Most of these benefits discussed above lead to lower unit production costs. To illustrate, more effective use of equipment and space leads to lower depreciation costs per unit produced, more effective use of labor results in lower labor costs per unit produced, and lower defects lead to lower cost of goods sold. The key principles describing Lean Manufacturing can be summarized as:

- Recognition of waste – The first step is to recognize what does and does not create value from a client's perspective. Any material, process, or feature that is not required for creating value from the client's perspective is waste and should be eliminated. To illustrate, moving materials among workstations is waste as it can potentially be eliminated.

- Standard processes – Lean requires an the implementation of very detailed production guidelines (labeled Standard Work), that clearly state the content, sequence, timing, and outcome of all actions by workers.

This eliminates variation in the way that workers perform their job.

- Continuous flow – Lean usually aims at the implementation of a continuous production flow that is free of bottlenecks, interruption, detours, back-flows or waiting scenarios. When this is successfully implemented, the production cycle time can be reduced significantly.

- Pull-production – Just-in-Time (JIT), Pull-production aims at producing only what is needed, when it is needed. Production is pulled by the downstream workstation so that each workstation should only produce what is requested by the next workstation (this approach has to be compared to a Push-production).

- Quality at the Source – Lean aims at eliminating defects at the source and for quality inspection to be done by the workers as part of the in-line production process.

- Continuous improvement – Lean requires striving for perfection by continually removing layers of waste (as they are uncovered). This in turn requires a high level of worker involvement in the continuous improvement process.

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