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Operations Research in Logistics

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Abstract: This study discusses the current scenario of Operations Research in the field of Logistics. Five sectors are considered in the study to form a brief understanding of how they use Operations Research techniques and why these techniques are used.

Objective: The objective of this study is to get an understanding of the workings of the Logistics industry from the perspective of Operations Research and using this understanding to gain a better picture of the shortfalls and limitations of current OR techniques in the sectors of manufacturing, procurement, healthcare and green logistics.

Keywords: Logistics, Supply Chain, Manufacturing Logistics, Green Logistics, Healthcare Logistics, Procurement Logistics, Operations Research.

Chapter 1: INTRODUCTION

Logistics is the management of the flow of goods between the point of origin and the point of consumption in order to meet some requirements, for example, of customers or corporations. The resources managed in logistics can include physical items, such as food, materials, animals, equipment, and liquids, as well as abstract items, such as time, information, particles, and energy. The logistics of physical items usually involves the integration of information flow, material handling, production, packaging, inventory, transportation, warehousing, and often security. The complexity of logistics can be modeled, analyzed, visualized, and optimized by dedicated simulation software. The minimization of the use of resources is a common motivation in logistics for import and export.

Logistics has been a very important industry historically since the world revolved heavily around trade in the early centuries. That said, while the industry itself has matured due to several advancements both in terms of technology and in the needs and demands of customers, it still plays a key role in industry and trade as we know it.

While we will take a brief look at a few industries that rely on operations research techniques for logistics later, we would point out a few facts about the current state of logistics and sum it up in a nutshell.

Logistics Industry Facts

It is estimated that in just eight years, The global logistics market will be worth $15.5tn with 92.1bn tonnes of goods being handled within eight years [1] However, not all is good for logistics, especially since in India it is faced with issues such as infrastructure, FDI norms, demand management and supply chain management, and demand patterns, among others.

The top contributors to the growth of logistics in India have been: the emergence of organized retail, increase in foreign trade and India becoming soon the manufacturing hub. [2]

Certain steps are being taken to limit the effects of the aforementioned issues including use of simulations and statistical data for optimizing resources.

Chapter 2: OPERATIONS RESEARCH IN MANUFACTURING LOGISTICS [3] [4]

Ever-increasing customer expectations and fierce competition in global markets force manufacturing companies to continuously enhance competitiveness to stay profitable. In recent years, they have realized that manufacturing logistics has a considerable potential to reduce costs, improve customer service and provide them with a competitive advantage. Operations research tools help researchers to analyse the data to improve productivity and efficiency, helping firms cut costs and maximize profits. This is done by software that develops quantitative models and analyse them, helping researchers to draw conclusions about the model and understand the scenario in the industry.

Operations Research (OR) is an umbrella term, covering a wide range of techniques that are based on different quantitative models. Some of the widely used techniques are:

- Linear programming,
- Discrete-event simulation,
- Queuing theory,
- Inventory theory.

Linear Programming: It is the process of taking various linear inequalities relating to some situation and finding the best value obtainable under that condition. It is used to help make decisions about allocation of resources

Discrete-event simulation: Discrete event simulation (DES) and system dynamics (SD) are two modelling approaches widely used as decision support tools in logistics. DES is mostly used at an operational/tactical level.

Queuing Theory: Queuing theory is a major topic of applied mathematics that deals with the phenomenon of waiting and arises from the use of powerful mathematical analysis to describe production processes.

Inventory Theory: OR techniques have successfully supported several key issues in inventory management. It is concerned with the use of OR techniques to support tactical and operational decisions related to controlling inventories of raw materials, components, and finished goods.

Chapter 3: OPERATIONS RESEARCH IN PROCUREMENT [5] [6] [7]

Procurement can be defined as the processes of acquiring or obtaining materials, services or products. The systematic coordination of all the processes required to attain any of these items is where logistics in procurement comes into the picture. Procurement is hence a vital aspect of most sectors, especially those which are material or raw material intensive.

Procurement can involve various aspects in itself such as making bids, price negotiations, delivery, making sure that the quantity in question is as per the requirements, etc. Logistics in procurement helps in ensuring that any input required can be obtained efficiently and at an economic cost. This, in turn, helps the company in earning greater returns and staying ahead of the competition.

According to DHL, one of the largest providers of logistics in the world, procurement logistics includes obtaining the following:

1. Auxiliary supplies
2. Operating supplies
3. Raw materials
4. Replacement parts
5. Purchased parts and similar items

Procurement logistics can be increasingly tedious in medium to large scale operations due to reasons such as: Ensuring that the various departments involved in the exchange of materials are well coordinated.

- Coordinating with the suppliers, agents, individuals who supply the necessities and maintaining a professional relationship with them.
- Managing the various processes involved in procurement such as shipping and delivery whichever can be extremely sensitive especially when the shipment involves capital intensive items.

Being aware of the current market scenario is very important for any company since cost pressures and fluctuations can drastically change the cost of inputs. Managing the allocated funds can hence often come to picking the most economical deal for the materials required, picking the best method of shipment within the time constraint, etc. It is because of this that companies have started investing heavily in procurement management. Procurement management has also brought about positive results, one such example of which would be Schiesser AG.

Linear programming in procurement

The techniques employed in the case study can help in solving problems related to time constraint. Linear programming is a mathematical model which represents alternate options, which in turn helps in assessing the best possible alternative within the constraints provided. Linear programming can be applied in the process of procurement to cut down costs or maintaining a budget while acquiring necessities. Linear programming problems are often compiled due to two needs which arise during procurement which is as follows:

1. It has a goal which is required to be achieved: An example of this would be a set budget for procurement of materials. Maintaining the set budget is necessary for a company to achieve its profit and economic projections.
2. These problems generally propose multiple different options: A practical example of this would be picking the right supplier within the budget and time constraint prevalent.
3. There are certain demands put forth by the situation: This, similar to the examples mentioned above, is clear by the company while communicating its needs and available resources to achieve those needs.
4. There is one optimal solution which is the best route to follow: After comparing the various alternatives, such as suppliers, there will be one supplier which provides the most sensible deal. Various factors will have to be considered in the process (eg: proximity, price, quality, etc)

Hence linear programming problem as a concept can be easily used to make the entire process of procurement logistics efficient.

Schiesser AG: Case Study

Schiesser AG is a German company which is a market leader in undergarment manufacturing within Germany. It saw a surge in demand internationally in the early 2000s. In order to cope with the increase in their procurement logistics requirements, they decided to outsource this process to Gebrüder Weiss. Gebrüder Weiss ranks amongst the top transportation companies in Europe. They implemented a system of information logistics to track information such as purchase orders and current transport status in order to make the procurement process efficient. This helped the company shortening their process time and substantially reduce their process costs.

Schiesser AG has since grown and a huge chunk of this growth can be attributed to successful procurement and supply chain management.

Chapter 4: OPERATIONS RESEARCH IN HEALTHCARE LOGISTICS [8] [9]

A hospital stay is always an unwanted experience for a person and the last thing hospitals want is for patients to wait because of overbooking due to poor scheduling. This is especially true because of two reasons - firstly because someone's life is on the line and secondly because hospitals focus a lot on the commercial aspect and many hospitals are now for-profit business units. A quick diagnosis can help detect a disease or illness in time for suitable treatment and save lives. However, unavailability of vacancies due to poor scheduling was a reality not so long ago and while things have drastically improved over the years perfect scheduling is still a dream for many hospitals.

Lack of planning, coordination, and communication in delivering health care services is the root cause of these delays, and Operations Research (OR) is what has helped hospitals to significantly reduce these delays. Not only does OR help significantly improve a hospital's operation but some complex problems presented by healthcare sector can lead to the development of new OR methodologies.

To ensure that the right goods and services are delivered at the right place, the right time, in the right quantity, at the right quality, and at the right price. These are called five measures which are known as 'fight rights of logistics'. They all play a vital and an equal role in improving the logistics of the hospitals.

Hospital logistics and operational management provide various kind of methods for analyzing using OR techniques. A particular area which has received considerable attention is nurse rostering i.e workforce scheduling. The roster through OR techniques tries to satisfy work regulations, distinguish between permanent and casual staff, assign suitably qualified nurses, distribute night and weekend shifts. Methods like linear programming, mixed integer, and goal programming as well as constraint programming methods have been developed to stimulate nurse rosters. But other problems are mostly over constrained so finishing a good quality solution requires advanced simulations and analyses which in turn takes up time and effort. Other approaches like simulated annealing, tabu search, variable neighborhood search, scatter search and genetic and memetic algorithms exist that take lesser time and yield satisfactory results.

Appointment scheduling uses OR methods such as mathematical programming (deterministic and stochastic), heuristics, queuing theory and simulation. Strategic operating room planning is another aspect of operations research in hospital logistics and mainly consists of resource allocation and capacity planning problems.

Hospital layout planning, while not as popular a logistical requirement as some of the others aspects mentioned, is still very important. The aim of this layout is to design a hospital, a clinic or a department to minimize the movement of the patient and resources like medical equipment and staff which accompanies with it. In order to achieve this, quadratic integer programming models were proposed by Butler et al(d) and Elshafei(e). Patient transportation is a variant of the dial-a-ride programming (DARP) and focuses on minimizing the cost and time taken for ambulances to reach their destination.

Moreover, OR has been used by the International Food Policy Research Institute to monitor a child nutrition program in Haiti (Loechl et al., 2005). The report describes the methods and results of OR undertaken to assess the effectiveness of World Visions food-assisted maternal and child health and nutrition (MCHN) program in the Central Plateau region of Haiti. The research had three main objectives:

- To assess the effectiveness of implementation and operations of the program relative to plans;
- To assess the quality of delivery of the various services; and
- To explore the perceptions of different stakeholders (i.e., beneficiaries and field implementer) regarding program operations and service delivery and the motivational factors that may affect staffs performance and job satisfaction.

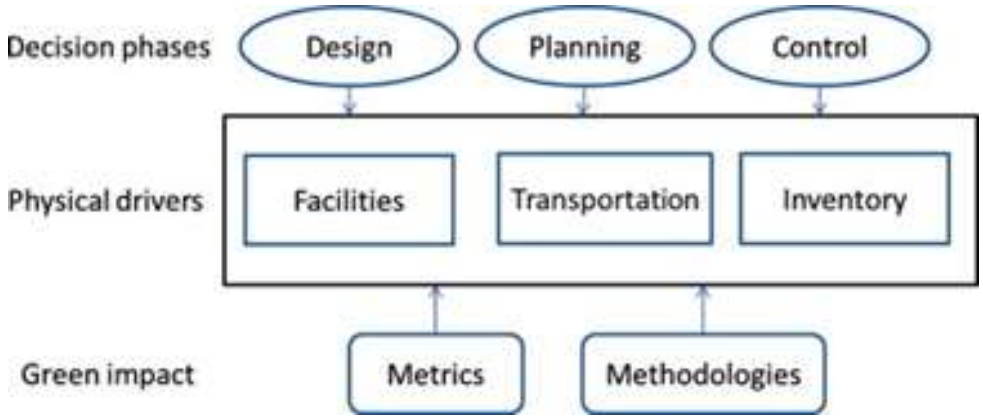
The overall goal was to identify constraints to effective operations; it was more important to identify and implement corrective actions that will ensure smooth implementation of the program and its various components. CBD is a good example of OR that eventually led the way to a key service delivery mechanism in a variety of health programs. OR showed that there is a demand for family planning services within communities and that CBD programs can increase family planning use even in settings where the health-care infrastructure is inadequate.

Healthcare managers are responsible for handling very complex and hard distribution of networks and inventory management without proper guidance as they are doctors with expert knowledge in medicine and not supply chains. This also sheds light on the ever-growing need to study operations research regardless of the industry due to its vast practical applications.

Chapter 5: OPERATIONS RESEARCH IN GREEN LOGISTICS

Environmental issues are ever-increasing and it is imperative to take preventive action while we still have the time to make a difference. Operations Research (OR) focuses heavily on constraints, limiting factors, tradeoffs, and choices. As a result, it is now possible, due to OR techniques, to see the environmental implications of business decisions. For instance, while switching over to recyclable and eco-friendly raw material may cause a marginal increase in costs, it will have a significant impact on the environment implying that the firm should strongly consider it. The main drivers that affect environmental change are:

- The physical drivers behind a supply chain
- Transportation
- Products & inventories
- Facilities.



With respect to the environment, transportation is the most visible aspect of supply chains. Transportation CO_2 emissions amount to some 14% of total emissions, both at global and EU level. There are four choices with respect to transportation which are supported by OR models, namely, mode choice (or modal split), use of intermodal transport, equipment choice and fuel choice.

We earlier mentioned recyclable products. Supply chain management and OR also takes into consideration the product lifecycle. This is to provide a holistic understanding of how the product impacts the environment after it has been manufactured by the firm. A few items are considered while analysing the product life cycle: first, the way they have been produced; second, the way they have been transported and waiting for use; third, whether their value can be recovered after their use. Packaging and returnable transport items are also considered.

Operational control of supply and transport chains

It is important to take into consideration how many kilometers the transport trucks run since they directly affect three of the most important parameters used while taking a decision - cost, time and emissions. Vehicle Routing Packages (VRP) are designed specifically to tackle this issue and to design the optimum route for a transport truck to follow.

Technique

One technique that is widely used is Multi-Criteria Decision Making (MCDM). This primarily deals with the efficiency of tasks and aims to reduce the total number of activities. It is also said that MCDM techniques can help in identifying synergies between cost and environmental objectives.

Operations Research in green logistics, then, is not just limited to one particular sector but instead focuses on all sectors. An example would be a ship reducing its speed to 18 knots resulting in fuel savings of 30% and recycling of discarded raw material while producing a paper to minimize wastages.

CONCLUSION

While limited examples were taken into consideration when studying about operations research techniques in logistics, we can conclude that advancements made in this field due to technology, mathematics, and statistics have helped achieve accuracy in simulations, predictions and general planning and scheduling. As a result, businesses are now much more profitable and waste less, hospitals are more efficient, resources can be procured at the cheapest rates and analyses between production decisions and environmental impacts can be taken into consideration.

Several complex models, simulations, and techniques are used in order to achieve these things and the importance of professional operations researchers are now being realised due to the sheer benefits that a company would receive. This change in mindset or change in demand is what will be the driving force for continuous improvement and optimization.

That said, there is still room for improvement and given the continuous research to find more efficient ways to perform tasks, advancements in this field will most likely be a constant, with each advancement improving the accuracy of predictions and analysis.

LEARNINGS AND RECOMMENDATIONS

1. Massive advancements have been made in the field of operations research in logistics and this has helped cut costs and optimize profits by a massive margin.
2. Due to the wide availability of software, it has become relatively straightforward to create complex simulations, estimations, and predictions. Analysing them is the challenging aspect.
3. Limitations do exist and they mainly deal with either the accuracy, complexity of results or time taken in order to complete the simulations and analyses.
4. At the end of the day due to variables such as demand patterns, predictions are unlikely to equal actuals.
5. Given that logistics is an industry with such a massive growth, constant innovation is necessary in order to stay ahead or at par with the competition which forces firms to invest heavily in research and analysis.

A FEW AREAS FOR FURTHER RESEARCH

1. Analysing trends to study the effectiveness of OR techniques with time.
2. Shortcomings of existing OR techniques sector-wise.
3. A comprehensive OR technique taking into consideration all relevant variables.

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