USE OF OPERATIONAL RESEARCH METHODS IN LOGISTICS

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Abstract

The article deals with use of operational research methods in logistics field. Most frequently used methods within logistics are: theory of charts and grids, special methods to solve transportation tasks, distribution problems and naturally methods of mathematical programming (most often used is linear programming). Referred methods can significantly influence e.g. moodiness of production process at plant and improve management and planning of logistics processes. The article also emphasizes importance of acquaintance of operational research methods (operational research) as competitive advantage for university graduates, which become part of company management by accepting right decisions at industrial plants.

Keywords: Operational research, operational research methods in logistics, distribution problems, linear programming, logistics processes

1. INTRODUCTION

In a complex activity like logistics, problem solving by assumptions of a simple cause-and-effect relationship alone is not sufficient. Optimum plan should be derived through the analysis and comparison of many alternative case studies simulating the behavior of logistics organization or processing system under the premises based on present situations or future planning. This means that application of the operational research methodology based on mathematical process is strongly required. [1]

2. LOGISTICS

Logistics is a discipline that deals with the systemic solution, planning, synchronizing, implementation and coordination of material flows and associated information and cash flows from the supplier to the enterprise, within the enterprise and from the enterprise toward the customer. Logistics is focused on meeting the customers needs as the final effect. The final effect is reached with the highest flexibility, precision and economy." [2]

The main features of logistics are summarized on the basis of several logistics definitions: [2, 3]:

- The scope of the logistics is transportation, materials handling and storage of all materials, intermediate products and products on the entire route from the supplier through the enterprise toward the customers.
- The content of the logistics is organization, planning, management, implementation and control of all processes of moving and storage processes in production and circulation, the material flow present the implementation of physical process, and other activities are related to the information flow.
- The role of logistics is the overall optimization of material flow in production and circulation. The tool for optimization is a connection of the individual subsystems into an integrated system. Material flow and related information flow is coordinated and managed in the mentioned system.
- Logistics means not only systematic thinking but also a new organization, with the emphasis on the integration of individual processes and the global view in order to optimize all related processes.

The logistics mainly solves problem of specifying the functional, organizational, personnel and material resources which enable to improve and optimize the information, materials and value flow within the whole

enterprise. Thereby logistics acquires integration function. "Logistics can be generally understood as a systematic discipline that deals with overall optimization, coordination and synchronization of all activities. Activity chaining is essential for flexible and effective achievement of the final (synergistic) effects." [2]. According to definition, the scope of logistics is very broad.

According to [3], the logistics can be understood in three basic levels of enterprises activity:

- In the area of information and material inputs to the manufacturing organization - the purchase (acquisition) logistics,
- In the area of manufacturing products - production logistics,
- In the area of product outputs and information from production organization - distribution logistics.

Exact methods based on the knowledge of exact sciences as mathematics, physics, and biology - applied to decision-making processes in diagnostic and optimization considerations - are widely used in logistics. [6]

3. OPERATIONAL RESEARCH

The scope of operational research (OR) is the study and analysis of operations and processes that are in progress or planned in a particular organizational unit (enterprise, factory, workshop, etc.).[4]

Many definitions have been given for OR. In general, however, as shown in **Fig. 1**, the term indicates a methodology in which corporate and social activities producing goods and services are understood as a system which outputs results when inputs are given, the system of those basic activities is constructed as a mathematical model, and problems regarding the operational methods of the system are analyzed using mathematical tools conforming to the purpose in order to produce the optimum solution. In practice, the problem finding and derivation of solutions are carried out by using a variety of techniques, such as mathematical and statistical analyses, system simulations, optimization algorithms, etc.[1]

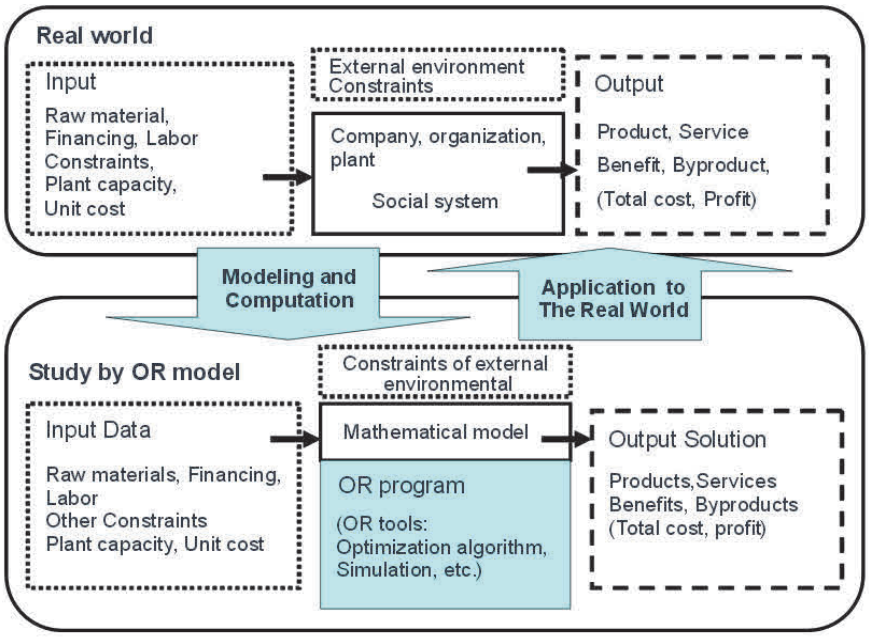

Fig. 1 Concept of study by OR model [1]

For example, Operations Research, or **operational research** in the U.K, is a discipline that deals with the application of advanced analytical methods **to help make better decisions**. The terms management science and analytics are sometimes used as synonyms for operations research. [5]

Logistics as an integral discipline does not have its own methodology and use the methods and principles of technical and economic sciences. The most commonly used methods in logistics are divided as follow [6]:

- The methods mainly used for analysis of the logistics process, and materials movement.
- **Mathematical methods of operational analysis.**
- Graphic methods (**graph theory, method of network analysis**, various types of diagrams).
- **Simulation methods -** simulation can be used for designing the new system, as well as the analysis and elimination of weak points in the production system.
- Methods for planning and forecasting procedures in logistics for the future planning periods.

The methods of operational analysis that are frequently used in logistics, production enterprises including the following methods: the graph and networks theory (scheduling tasks in production logistics), linear programming (optimization of transport distances, transport costs, etc.), methods of network analysis, iinventory theory models.

3.1. Graph and networks theory

Methods of graph theory are also used for modelling transport systems. Many of the real systems can be represented as graphs, which consist of joints and edges (line between joints). All transport (distribution) networks can be illustrated into collection of joints and edges (**Fig. 2**). Joints in the network are interpreted as distribution centres and edges as a connector between them. Graphic presentation of the real system is very illustrative and understandable even for layman in the area of mathematical modelling; as results of mentioned, models of this type are applied quite often. Methods of graph theory are applied as diagnostic and optimization methods (determining optimal flows in networks to optimize the transport service, travelling salesman problem). These methods are needed for an accurate representation of the various procedures and processes in the analysis of the material and information flows. The overall procedures and movements can be broken down into small sub-sections.

Fig. 2 Example of distribution network - Slovak Telekom, a.s. network [7]

Within the graph theory, following algorithms are taught at the Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava (STU MTF): Ford - Fulkerson and Dantzig to find the shortest path in the network, searching for the longest path in the network, Euler cycle and the Chinese postman and more.

3.2. Linear programming

The theoretical foundation of linear programming (LP) is a linear algebra and the father of LP is prof. Dantzig. LP models and methods are used to solve the tasks, for which are typical multivariable solutions and in which can be assumed that among the variables is only linear dependence. According to previous sentence, the

subject of LP is the solution of linear optimization problems, which are a special case of the general problems of mathematical programming.

Methods that were developed within the theory of LP are at once relatively simple in its mathematical structure and applicable to solve a large number of different tasks. The general task of LP is to determine the vector of variables $\bar{x} = (x_1, x_2, ..., x_n)$ for which the function acquires the extreme (maximum, minimum):

$$\begin{aligned} & z = c_1 \cdot x_1 + c_2 \cdot x_2 + \cdots + c_n \cdot x_n \overset{!}{=} \max .or \min . \\ & a_{11} \cdot x_1 + a_{12} \cdot x_2 + \cdots + a_{1n} \cdot x_n = b_1 \\ & a_{21} \cdot x_1 + a_{22} \cdot x_2 + \cdots + a_{2n} \cdot x_n = b_2 \\ & \vdots \\ & a_{m1} \cdot x_1 + a_{m2} \cdot x_2 + \cdots + a_{mn} \cdot x_n = b_m \\ & x_j \geq 0 \quad , \quad j = 1,2,\ldots,n \end{aligned} \tag{1}$$

a_{ij}, b_i a c_j are constant factors and $m \leq n$ (i = 1, 2, ..., n). The formulation of LP (1) is also called standardized (canonical) form of LP problem, or linear optimization model.

Among the methods for solving LP, the **special methods for solving distribution problems** are mostly used in logistics (northwest corner method, index method, Vogel approximation method, modified method of Hungary method.

3.3. Methods of network analysis

Network analysis is a part of mathematical programming. Its theoretical basis is graph theory and probability theory. Research subject is the design, implementation and application of mathematical models of complex set of activities (projects) forming a follow-up process. There are technological and organizational relations among these activities. It means that an activity may begin only after the completion of some other activities [4, 8]. Network analysis is used in the preparation, planning, management; coordination and control of complex tasks in various areas of economic activity where it is needed to analyse or optimize any network of interconnected and related items that have some connection between them. Therefore their application is in area of project management, where the elements present the key project activity in a mutual time relations. Another possibility of their use is in the field of **logistics and transport**, where the elements present centres and dependencies are surrounding (also time). Methods of network analysis are focused on calculating and optimizing critical paths among single elements. The methods of network analysis include: CPM (Critical Path Method), PERT (Program Evaluation and Review Technique), GERT (Graphical Evaluation and Review Technique), MPM (Metra Potential Method).

3.4. Inventory theory models

Inventory management systems are priority in logistics. There are various forms and methods of inventory management, their optimization, timing analysis, and etc. Scientific approach to the inventory management is based on the use of mathematical models of stock movements. **The inventory theory** deals with the issues of determining the size of inventories, concepts for their complementarities and compiling the models for this purpose. The purpose of inventory theory is to optimize the supply management process. Optimality criterion is generally the size of the total inventory cost and the goal is to minimize them. In practice, there are a wide range of situations related to inventory management, thus the wide variety of **inventory models** is equivalent. Each particular case requires an individual approach. [8]

The costs related to the inventory movements management can be divided into costs that are directly **proportional to the size of the stock** (storage costs, cost for material handling, losses caused by spoilage,

losses caused by committing funds, etc.) and costs that are **inversely to the size of the stocks** (the costs for additional acquisition when the stocks are depleted, losses that arise due to stocks depletion, etc.).

For example: the total value of all inventory- including finished goods, partially finished goods, and raw materials- in the United States is more than a *trillion* dollars. This is more than $4,000 each for every man, woman, and child in the country. The costs associated with storing ("carrying") inventory are also very large, perhaps a quarter of the value of the inventory. Therefore, the costs being incurred for the storage of inventory in the United States run into the hundreds of billions of dollars annually. Reducing storage costs by avoiding unnecessarily large inventories can enhance any firm's competitiveness. [9]

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How do companies use operations research to improve their inventory policy for when and how much to replenish their inventory? They use scientific inventory management comprising the following steps [9]:

1. Formulate a mathematical model describing the behavior of the inventory system.
2. Seek an optimal inventory policy with respect to this model.
3. Use a computerized information processing system to maintain a record of the current inventory levels.
4. Using this record of current inventory levels, apply the optimal inventory policy to signal when and how much to replenish inventory.

The development of useful models for supply chain management currently is a particularly active area of research. Continued growth is occurring in the computerization of inventory data processing, along with an accompanying growth in scientific inventory management. [10, 11, 12]

4. CONCLUSION

Logistics lies at the heart of every organization, whether manufacturing or services, large or small, public or private, multinational or SMB. It is thus essential for all managers and business school graduates to master the fundamental concepts of operations research (management) and logistics and to be capable of choosing and applying the best methods for the situation throughout their career [13, 14, 15, 16].

Many universities has in their study programs subjects which teach and prepare graduates to do decisions they will face in their professional lives. Students/graduates then are able to decide not only based on recommendations from their environment, but after using a suitable exact method they can confirm/contradict correctness of their decision.[17]

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