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Module: Modelling Logistics Operations
M5X01280

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The roles of models in Logistics and Supply Chain

Table of contents

1. Introduction.....	2
<i>Figure 1. Materials requirements planning and modelling system to compute master production schedule (Source: Saphiro, 2007, p.362)</i>	<i>2</i>
2. Supply chain modelling systems.....	3
<i>Figure 2. An overview of simulation models and optimization models to support supply chain decision making (Source in Saphiro, 2007, p.10).</i>	<i>3</i>
3. Example case.....	3
4. Inventory models – the Economic Order Quantity (EOQ).....	4
5. Simulation software – AnyLogic.....	5
6. Conclusion	5
References	6

1. Introduction

According to Sussams (1992), a logistician defines a 'model' as 'a symbolic representation of features of the real world which are relevant to and sufficiently accurate for the purposes that the model user has in mind' (Sussams, 1992, page 3). Advances in IT is the major factor that has aided the development of integrated planning into supply chain management over the years. Models provide accurate and broad representations of supply chains for the managers to make the optimum decisions. The optimization model is critical because it provides a framework for integrating data and decision making' (Saphiro, 2007, p.257).

Today, supply chain modelling is a powerful tool used by managers to have a complex view of the supply chain and to analyse, optimise and simulate every characteristic of the SC from performing the daily operations until the point of determinate the long-term footprint (Dirlea, 2016).

Thiers and McGinnis (2011) address two types of models on global supply chain: *optimization models* and *simulation models*. Modelling systems and optimization models are successfully applied to the transportation modes, vehicles preparation and routing, warehousing and inventory-stocking activities in the logistics system and continuous research seeks to allow managers to apply these models in the decision-making (Saphiro, 2007).

In the last decades, software companies have been developing modelling systems for the MRP in order to help managers to achieve optimization for the production costs. The master production schedule (MPS) is a complex process required by the typical MRP system through which the company develops an elaborate production plans and purchase orders of parts and finished products. Saphiro (2007) illustrates in figure 2 the scheme of the MRP system that involves an MPS for finished products as an input.

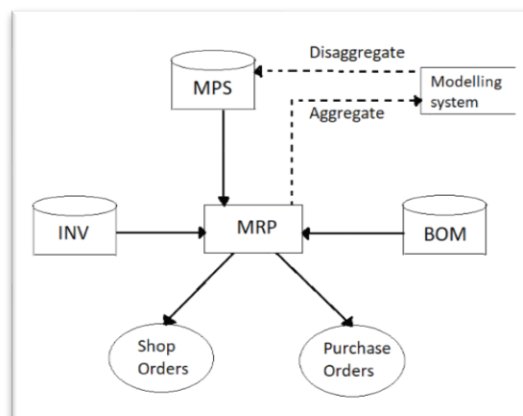


Figure 1. Materials requirements planning and modelling system to compute master production schedule (Source: Saphiro, 2007, p.362)

Advances in IT are playing a major role in the application of models and modelling systems within companies. Managers can easily access the database of a section of the SC and the related costs to help them build a particular model of the problem.

Experienced practitioners have determinate descriptive models as tools used provide a better understanding of the functional relationships in the organization and the exterior world. According to Saphiro (2007), these models refer to the following:

- Forecasting models that predict demand estimates over some time periods in the future for the raw materials cost, the finished products that the company sells, and other factors based on historical data.
- Cost relationships that describe direct and indirect costs as inputs to a SC optimization model and how they vary as functions of cost drivers.
- Simulation models that permit managers and analysts to study how supply chain and other systems will operate within the parameters set by practitioners or managers.

2. Supply chain modelling systems

The purpose of supply chain management is to minimize the cost of the total supply chain, in order to meet fixed demands and customer requirements. Designing and applying the supply chain modelling systems must merge with other systems that collect data and optimise other aspects of the company' SC. Saphiro (2007) summarizes the opportunities of applying SC modelling systems:

- a. For operational problems, the model allows the owners to deliver the milestone of the business model and identify the low-cost plans to meets customer demands.
- b. For tactical problems, models help plans and processes that can save time and money and maximize the net revenue while meeting customer demands and adding value. Models for tactical problems include decisions in logistics, manufacturing, suppliers and product development (b. Murray, 2019).
- c. For the strategic redesign of current networks, models allow managers rethink the way the business operates on the market and to seek new resources and technologies (an example of redesigning a current network (the warehouse) of a company is shown below).
- d. For the strategic design of a SC network for developing a new product line, models have significant importance because they analyse the costs among supply chain strategies.
- e. For tactical and strategic planning operations, SC decision database provides information about costs, inventories and activities of the transitional database. A sketch of the simulation models and optimization models is presented in figure 2.

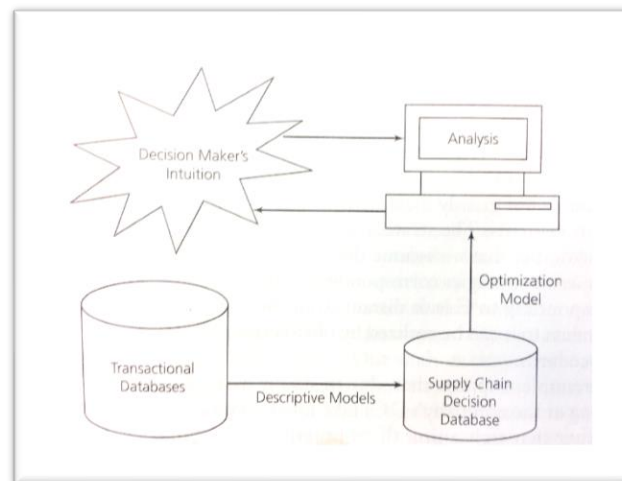


Figure 2. An overview of simulation models and optimization models to support supply chain decision making (Source in Saphiro, 2007, p.10).

3. Example case

Merkuryev et al. define order picking as the 'retrieval of products from specified locations according to customer orders' (Merkuryev et. al, 2009, p. 148). The models developed by research on order picking have been continuously focused in reducing the travel time or travel distance within the warehouse. Simulation modelling is a powerful tool used by today's businesses to efficiently design and optimize the warehouse layout and operations and to forecast and adapt to operational requirements. Customer order picking takes nearly 60% of all the labour operations in the warehouse (Merkuryev et al., 2009).

An example of a case, adapted from Gerardles et al. (2008) presents a manufacturer and distributor of house appliances from Portugal, F&F which was struggling to remain competitive on the market. About 95% of the manufactured product were distributed to customers around the country and 5% to customers in Africa in Spain. The company acquired 50% of its products from European countries, 25% from China and 25% were

acquired locally. The company's facility consists of 2 main areas: the assembly section and the picking section. The total area of the warehouse is 4000 m² and the company uses and owns approximately 1200 m² of the warehouse storage space.

The warehouse operations involve 'receiving, storage, picking consolidation, sorting and shipping and some value-added activities (labelling, repacking etc)' (Geraldes et al., 2012) which are daily performed by a team of 15 workers. During the first time of the day, in the morning, workers will carry out the receiving of items and storage and the picking operations. The second part of the day, in the afternoon, orders were checked for missing items, packed and prepared for shipping. These operations were performed while picking operation were still in progress.

One of the major problems the company started to face during the last years was the growing need for extra storage space due to 'the increasing variety of products available and to large inventory levels required to face long lead-times' (Geraldes et al., 2012).

Outdated items and pallets with slow moving stock items were a significant obstruction for efficient picking. Furthermore, the improper arrangement of the items on the picking routes and an inefficient layout of items on the shelves were the reason preventing the picker to minimise the travel time between picking locations.

The reason of wrong inventory management was the incapacity to determine demand forecasting for some time periods in the futures. Instead of having the most frequently picked items closest to the packing areas, some of these items were located on difficult access positions, allowing the picker to walk through the entire warehouse to process an order. Following a complex analysis of the situation, the company decided to redesign the warehouse in order to eliminate the outdated items, identify storage areas and to allocate the items to the areas.

In redesigning the warehouse, a mixed-integer programming model, that uses data readily available to the warehouse manager, was applied. Succeeding the implementation of the model, using LINGO 9.0 (Gerardes et al., 2009) and, after a rigorous analysis on the operations of the warehouse, F&F managed to relocate fast movers items at lower levels improving the picking operations, while items with low rotation life and replenishment were designated at the upper levels. As a result, the approach revealed to be appropriate for the new layout where an important storage reduction of about 40% was achieved.

The example presented the problem of a typical warehouse problem encountered by many organizations. While appropriate solutions vary by the products and items shipped, and from industry to industry, there are a number of good practices that can be undertaken by most companies.

Optimizing the warehouse processes within each business is a complex problem mainly because the development and implementation of descriptive models is needed but not sufficient for adopting effective decision making. For instance, providing accurate demand forecasts must be in conjunction with other data in building a holistic optimization model to determine which plants should produce a specific kind of products for specific distribution centres and markets, so the demand is met at minimal cost (Saphiro, 2007).

It is important to acknowledge that choosing the right order picking system depends on the requirements of each business. Some companies might have specific requirements, such as the size of items stored in the warehouse, the volume of customers' orders, the cost and complexity of the business (a. Murray, 2019) and many others that involves a unique picking solution.

4. Inventory models – the Economic Order Quantity (EOQ)

Saphiro (2007) states that although IT is increasingly enabling the development of modelling systems in all the industries, it is still unclear for managers how to fully optimize the supply chain decisions by successfully implementing and applying models of the supply chain data.

Inventory control is very important for every kind of business. Keeping the optimum level of inventory to satisfy the needs of the customers is a task that all the managers must

undertake. Economic order quantity (EOQ) is an example inventory model that applies mathematical models to real life problems.

EOQ helps businesses to determine the inventory reorder point, allowing sufficient inventory to fulfil customer orders. The EOQ formula provides better outcomes when demand, holding costs and ordering are constant over time.

5. Simulation software – AnyLogic

AnyLogic is a computer-based simulation model that uses algorithms and equations to solve complex systems and real problems in an efficient way. This powerful simulation software is applied in many industries such as supply chains, transportation, manufacturing, road traffic, marketing, business processes and many others, industries that need to provide a way to examine and test different scenarios, and eventually make the right decisions before applying to the real world processes. As emphasized by Saphiro 'simulation models are descriptive models that permit managers and analysts to study the dynamic behaviour of supply chain and other systems' (Saphiro, 2007, p.233).

AnyLogic simulation modelling software is used by over 40% of Fortune 100 companies (AnyLogic, 2019), such as DHL, Google, Airbus, FedEx, Ford Motor Company and many others. This leading simulation modelling software for company applications, allows analysts, managers and practitioners to optimize complex processes and systems and to gain a much wider insight across the industry. It provides visualisation and animation tools that help practitioners build models with customised look and enhanced visual impact.

The complexity and flexibility of the modelling software enables the users to simulate and model multiple operations of the business, including tactical and strategic operations, that result in more efficient problem solving and profitable decision making (PMC, 2019).

6. Conclusion

Rapid developments and advances in IT have been the major determinants, over the years, for the supply chain management and logistics. When the manager is confronted with the situation of making efficient and effective decisions for the business, models have proven to be a useful aid that supplies tools for the accurate and broad representations of the business. The models adopted by practitioners and managers on the functional relationships in the supply chains and the real-world addresses two types of models: optimization models and simulation models (part of the descriptive models).

Supply chain modelling systems are applied in the daily problems of the supply chains. Those problems relate mostly to the operational and tactical operations, to the strategic redesign of the existing networks and the development of a new product line. Although, in many of these cases, the opportunities of developing accurate descriptive and simulation models is necessary and efficient, is not always enough in making and effective decision.

An example case study of a model used to strategic redesign a warehouse for a distributor and manufacturer of house appliances was presented. After an elaborate analysis on the operational activities within the warehouse's layout, practitioners confirmed the redesign of the warehouse. The company's focus was to eliminate unnecessary inventories and outdated items that were obstructing the workers in achieving the efficient picking process. The model, mixed-integer programming, allowed the sizing of functional areas within the warehouse and properly allocation of the items within these areas. The positive outcome of the optimization within the warehouse allowed the travel distance and travel time to be reduced, resulting in a highly improved picking process.

Controlling the optimum level of inventory for the business operations in order to have enough to satisfy the needs and requirements of customers is a very important task for the managers. An adequate inventory model for identifying the optimal number of items or product units to order is the economic order quantity (EOQ). The EOQ applies mathematical models to real world problems.

Additional to the mathematical problems applied in the supply chain, simulation modelling software are a way to test and examine multiple scenarios that will help the managers,

engineers or business analysts to make the right decision before applying it to the real-world problems. AnyLogic is one of the globally used modelling software for business in providing important methods for analysing complex systems and return valuable solution. It provides visualisation and animation tools that help practitioners build models with customised look and enhanced visual impact.

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