EAI Endorsed Transactions
on Scalable Information Systems

Research Article EAI.EU

Recent Trends and Advancements in Inventory Management

[1,*] Ankit Dubey, and [1]R Kumar

[1]VIT-AP University, Inavolu, Beside AP Secretariat, Amaravati AP, India

Abstract

In this paper, we categorise and critically evaluate the current modelling and analysis approaches and procedures created by researchers and scientists in inventory management systems across different sectors such as healthcare, supply chain, and routing problems. Furthermore, we discuss recent trends and advancements in inventory management systems that deal with shortage. Based on our literature review, we propose a comprehensive research structure that is appropriate in the current environment and helpful in future study directions.

Keywords: Inventory management, Supply chain, Economic order quantity, EOQ

Received on 29 August 2023, accepted on 18 October 2023, published on 05 December 2023

doi: 10.4108/eetsis.4543

*Corresponding author. Email: ankitd.vit22@gmail.com

1. Introduction

Operational research (OR) was developed during World War II [1939-1944] by Watt and Rowe when there was a dire need to manage scarce resources [1]. OR involves the use of analytical methods to design, analyze, and improve systems and processes in a wide range of fields, including manufacturing [2], transportation [3], logistics [4], healthcare [5], finance [6], and telecommunications [7]. It aims to maximize efficiency, minimize costs, and improve overall performance through the use of mathematical models and algorithms. According to Stafford Beer [8], "Operational research is the use of scientific methods to provide solutions to problems arising in the direction and management of large systems of men, materials, machines, and money in the business, industry, defense, and government." Additionally, we have also discussed Some of the major contributions to operational research in below table 1 and picture 1.

Table 1: Influence of Operations research in the real-life applications by the different researchers

Authors	Years	Application	Significance
Matsumoto & Mays [9]	1985	Upper bound problem	Using the Dual Simplex method is a recommended strategy for solving the Generalized Upper Bound (GUB) problem.
Bektas & Elmastas [10]	2007	Bus routing problem (SBRP)	To solving the school bus routing problem (SBRP) using integer programming technique.
Christine Solnon [11]	2008	sequencing problem	The car sequencing problem can be addressed by utilizing ant colony optimization (ACO) methodology.

Liu & Zhang [12]	2009	Quadratic programming	To solving parametric quadratic programming problem using parametric pivoting algorithm.
Yadav et al. [13]	2020	healthcare inventory systems	The concept of genetic algorithm is used to handle the healthcare inventory systems such as blood bank storage problems.

A pictorial representation of the Table. 1 is shown in Fig. 1.

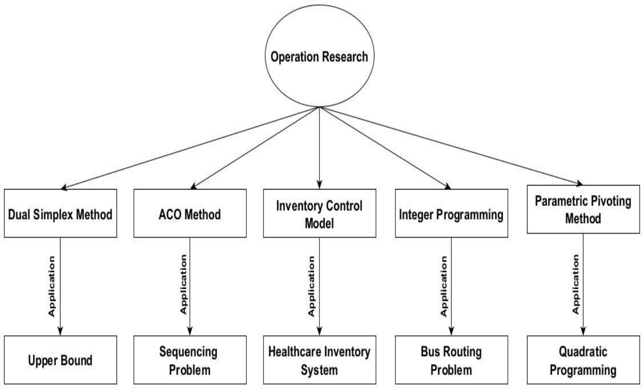

Fig. 1: Pictorial representation of Table 1

Overall, the goal of OR is to provide decision-makers with the tools and information they need to make informed decisions that will improve the performance and efficiency of their organizations. Inventory models are a common topic in operations research.

In this paper, our aim is to discuss the review of the inventory model. Inventory models in operations research typically involve analyzing the trade-offs between holding inventory (i.e., the cost of storing goods) and the costs associated with ordering and acquiring inventory (i.e., the cost of ordering, shipping, and handling goods). By optimizing these trade-offs, businesses can determine the optimal level of inventory to maintain in order to minimize costs while still ensuring that they have sufficient inventory to meet customer demand. Ford W. Harris [14] first proposed the inventory model, often known as the economic order quantity (EOQ) model, in a 1913 article titled "How Many Parts to Make at Once." However, in 1940, R. H. Wilson in the improved upon the idea and made it more widely used. To reduce inventory holding and ordering costs, several companies employ the Economic Order Quantity (EOQ) model in their inventory management practices. The Inventory Control Model can be used in a wide variety of applications such as supply chain [15], vendor problem [16], healthcare inventory system [17], service level inventory system [18], and so on. According to Robert A. Johnson, "Inventory models are analytical tools that help managers determine the most efficient and cost-effective inventory levels and reorder points for a given level of demand uncertainty. Some of the major contributions to Inventory control model are also discussed in table 2 and Fig. 2.

Table 2: Applications of Inventory model in different areas

Authors	Year	Applications	Significance
Pan and Hsiao [19]	2005	Inventory models that incorporate controllable lead time and backorder discounts.	The proposed inventory system by the author allows for shortages, and offers negotiable lead times and backordering options.
Nasiri et al. [20]	2010	Supply chain	To solve the model, we utilized Lagrange Relaxation with a sub-gradient search approach, applying it to a mixed integer non-linear programming problem.
Al-Qatawneh & Hafeez [21]	2011	Healthcare	to handle the logistics cost optimization in healthcare by using a multi-criteria inventory classification method.
Rabbani et al. [22]	2018	Vendor problem	Using metaheuristic algorithms to manage deteriorating inventory items with vendor control.
Jiang et al. [23]	2019	Service level inventory system	To solve this system author used the heuristic algorithm approach.

A pictorial representation of the table 2 is shown in below Fig. 2.

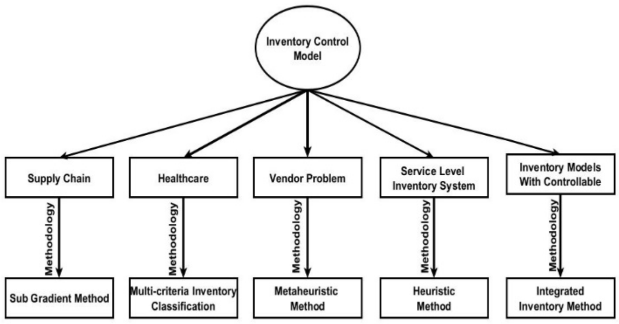

Fig. 2: Pictorial representation of Table 2

Overall, inventory models are a crucial component of operations research because they assist companies in making defensible choices regarding the amount of inventory to hold and the timing of new inventory orders with the aim of reducing costs and maximizing efficiency. In addition, we can define inventory models as a group of analytical methods that allow companies to weigh the costs of stock-outs against the expenses of maintaining inventory in order to maintain the proper level of inventory on hand to satisfy consumer demand. Upon reviewing the introduction, it becomes evident that extensive research has been conducted on the inventory problem. However, there is a significant lack of research on inventory-related issues that arise in real-world applications. As a result, this study aims to discuss recent advancements and trends in inventory management systems. With this in mind, the primary objective of this paper is to provide insights into evolutionary methods commonly described by inventory theory, highlighting key aspects of inventory and supply chain management. By summarizing different inventory models, this review article aims to assist researchers and students in gaining a comprehensive understanding of the field. Furthermore, this paper will discuss the existing challenges in inventory management, including routing problems, customer service management, supply chain, production management, and blood bank issues.

The organization of the paper flow is as follows in the following sections. Section 3 gives an overview of the inventory management problem with shortage and the related research that has already been done with the on-trend extensions individually and summarized the contribution made by various researchers on these models will be discussed in a tabular form. Section 4 summarizes the conclusion study on inventory management with shortage.

2. Recent Trends in Inventory Control model

Pasandideh et al. (2010) [24] conducted a study on the partnership between retailers and suppliers using a vendor-managed inventory (VMI) model. To develop their mathematical model, Pasandideh et al. (2010) [24] made several assumptions, including: a single-supplier-single-buyer supply chain with only one item, assuming deterministic customer demand, assuming instantaneous delivery of orders with zero lead time, allowing shortages that are completely backlogged, and assuming an infinite production rate. This model was used to analyze the inventory management strategies used before and after the introduction of VMI for a two-level supply network with a single supplier and buyer. Several numerical examples were utilized to illustrate the use of the suggested strategy, using various buyer (21,30,45) and supplier (75,40,150) ordering costs, respectively. Pasandideh et al. (2010) model results revealed that only in a specific situation, where shortages are backlogged, can VMI deployment in EOQ models lower total supply chain costs. ([ref [24], page 337 eq. 85]. So, it is obvious that the research's proposed model is typical of a particular kind of supply chain. However, the outcomes are only valid under the premise that the assumptions are true. Subsequently, Pasandideh et al. (2011) [25] present a new work that use genetic algorithms to solve the inventory model.

Pasandideh et.al. (2011) [25] have expanded the EOQ model. In this article, there is only one retailer and one supplier, and no products are involved. The supplier's inventory cost is equivalent to the supply chain's overall inventory cost, it is the supplier that sets the production schedule and quantity. Several presumptions were made by Pasandideh et al. (2011) [25] implemented backorders and shortages. During the planned period, all product prices are held constant, and there is no expected increase in wait time for delivering orders. Furthermore, there are no quantity discounts, and the production rate is limitless (i.e., EOQ model). All product demand is predetermined, and the provider only has so much storage space. In addition, there is a cap on the sum of all orders. They proposed a genetic method and modelled the issue as an NIP (nonlinear integer programming) problem. Nia et al. (2015) [26] later expanded on Pasandideh et.al. (2011) [25] original research by taking into account the hybrid genetic algorithm to address the vendor management challenge.

Nia et al. (2015) [26] present a novel EOQ model with multiple items and constraints for a green supply chain with a single supplier and one buyer. In this approach, n-items are distributed between a single retailer and a single manufacturer. All items may be placed on backorder, there is no assumed cap on production expenses, and fixed cost per unit. There is a maximum allowable order quantity for all products, storage space is finite, and client demand for all products is predictable. However, backorders apply to all products and have a linear cost per unit per time unit. During the preparation process, neither quantity discounts nor price modifications are offered, and all orders are fulfilled without delay. Additionally, there are limits on the order amount and the number of pallets that can be requested for each product. The goal of the suggested hybrid meta-heuristic approach is to decrease supply chain costs by optimizing them with a combination of an imperialist competitive algorithm (HGA) and a genetic algorithm. The efficiency of the proposed algorithm was evaluated using several numerical examples of varying sizes. The results demonstrated that the hybrid method generated optimal solutions that were much closer to the lower bounds than those obtained using either method alone. To verify the efficacy of the proposed strategy, we employed a GA to solve a relaxed model whereby all variables were considered as continuous and compared the resulting values to lower bounds.

Taleizadeh et al. (2013) [27] created an inventory control models to identify the shortage quantities and optimal order of perishable goods during a special sale offered by the supplier by taking several assumptions into account, including that all unsatisfied demand would be backordered, the special order, shortages were allowed, could be placed only during the time of the current order, and the discounted price was only available for a limited time. They also investigated some scenarios based on the buyer's initial replenishment policy, the occurrence of the special period during either the positive or negative inventory level of previous regular period, and whether the buyer took advantage of the special order.

In conclusion, the studies discussed above have proposed different mathematical models and algorithms to improve inventory management practices in supply chains. Each model has made certain assumptions and focused on specific types of supply chains, products, and objectives. It is important to note that the applicability of these results may be limited to certain situations where the assumptions hold. Therefore, further research is needed to develop more comprehensive and flexible models that can accommodate various types of supply chains, uncertainties, and environmental factors.

Conclusion

We conduct a critical review and classification of the current approaches and methodologies used by researchers and scientists in modeling and analyzing inventory management systems. Our analysis covers a variety of sectors, including healthcare, supply chain, and routing problems. Additionally, we examine recent advancements and trends in inventory management systems that address shortages. Drawing on our extensive literature review, we propose an integrated research framework that is relevant to the present-day context and suggest avenues for future research. Our forthcoming objective is to undertake an extensive examination of the existing literature on fuzzy theories, encompassing concepts such as triangular, trapezoidal, and others. This undertaking is prompted by our conviction that reliance solely on classical theory is inadequate in effectively managing uncertainty. By placing particular emphasis on this perspective, we aim to delve more profoundly into the body of literature pertaining to fuzzy theory, thereby augmenting our comprehension in this domain.

Acknowledgements.

I would like to express my gratitude to the 2nd EAI International Conference on Intelligent Systems and Machine Learning (ICISML-2023) for providing us with the opportunity to present our work. I am sincerely appreciative of the Editor-in-Chief and all the reviewers.

References:

[1] J. K. Sharma, Operation research: theory and application, 4th edition, Macmillan Publisher India Ltd, 2009.

[2] A. Kusiak, "Artificial intelligence and operations research in flexible manufacturing systems," *INFOR: Information Systems and Operational Research,* vol. 25, (1987): pp. 2-12.

[3] T. Bektaş, J. F. Ehmke, N. P. Harilaos and J. Puchinger, "The role of operational research in green freight transportation," *European Journal of Operational Research,* vol. 274, (2019): pp. 807-823.

[4] R. Dekker, J. Bloemhof and I. Mallidis, "Operations research for green logistics – An overview of aspects, issues, contributions and challenges," *European Journal of Operational Research,* vol. 219, (2012): pp. 671-679.

[5] R. Sachdeva, T. Williams and J. Quigley, "Mixing methodologies to enhance the implementation of healthcare operational research," *Journal of the Operational Research Society,* vol. 58, (2007): pp. 159-167.

[6] L. C. Thomas, "Consumer finance: challenges for operational research," *Journal of the Operational Research Society,* vol. 61, (2010): pp. 41-52.

[7] G. C. Pentzaropoulos and D. I. Giokas, "Comparing the operational efficiency of the main European telecommunications organizations: A quantitative analysis," *Telecommunications Policy,* vol. 26, (2002): pp. 595-606.

[8] S. Beer, "Operational Research," *JESTOR,* vol. 6, (1959): pp. 1-20.

[9] J. Matsumoto and L. W. Mays, "Dual simplex method for GUB problems," *Journal of Optimization Theory and Applications,* vol. 45, (1985): p. 113–122.

[10] T. Bektaş and S. Elmastaş, "Solving school bus routing problems through integer programming," *Journal of the Operational Research Society,* vol. 58, (2007): p. 1599–1604.

[11] C. Solnon, "Combining two pheromone structures for solving the car sequencing problem with Ant Colony Optimization," *European Journal of Operational Research,* vol. 191, (2008): p. 1043–1055.

[12] Y. Liu and Z. Zhang, "Parametric pivoting algorithm for parametric quadratic programming problem," in *Second Pacific-Asia Conference on Web Mining and Web-based Application*, 2009.

[13] A. S. Yadav, N. Ahlawat, N. Sharma and A. Swami, "Healthcare systems of inventory control for blood bank storage with reliability applications using genetic algorithm," *Advances in Mathematics: Scientific Journal,* vol. 9, (2020): p. 5133–5142.

[14] F. W. Harris, "How many parts to make at once," *The Magazine of Management,* vol. 10, (1913): pp. 135-136.

[15] B. Sarkar, "A production-inventory model with probabilistic deterioration in two-echelon supply chain management," *Applied Mathematical Modelling,* vol. 37, (2013): pp. 3138-3151.

[16] M. Hariga, M. Gumus, A. Daghfous and S. K. Goyal, "A vendor managed inventory model under contractual storage agreement," *Computers and Operations Research,* vol. 40, (2013): pp. 2138-2144.

[17] E. Saha and P. K. Ray, "Modelling and analysis of healthcare inventory management systems," *Opsearch,* vol. 56, (2019): p. 1179–1198.

[18] F. Y. Chen and D. Krass, "Inventory models with minimal service level constraints," *European Journal of Operational Research,* vol. 134, (2001): pp. 120-140.

[19] J. C. H. Pan and Y. C. Hsiao, "Integrated inventory models with controllable lead time and backorder discount

considerations," *International Journal of Production Economics,* vol. 93, (2005): p. 387–397.

[20] G. R. Nasiri, H. Davoudpour and B. Karimi, "The impact of integrated analysis on supply chain management: a coordinated approach for inventory control policy," *Supply Chain Management: An International Journal,* (2010): p. 277–289.

[21] L. Al-Qatawneh and K. Hafeez, "Healthcare logistics cost optimization using a multi-criteria inventory classification," *International Conference on Industrial Engineering and Operations Management,* 2011.

[22] R. H. L. M. Rabbani and H. Farrokhi-Asl, "Vendor managed inventory control system for deteriorating items using metaheuristic algorithms," *Decision Science Letters,* vol. 7, (2018): pp. 25-38.

[23] Y. Jiang, C. Shi and S. Shen, "Service level constrained inventory systems," *Production and Operations Management Society,* vol. 28, no. 9 (2019): p. 2365–2389.

[24] S. H. R. Pasandideh, S. T. A. Niaki and A. Roozbeh Nia, "An investigation of vendor-managed inventory application in supply chain: the EOQ model with shortage," *The International Journal of Advanced Manufacturing Technology,* vol. 49, (2010): p. 329–339.

[25] S. H. R. Pasandideh, S. T. A. Niaki and N. Ali Roozbeh, "A genetic algorithm for vendor managed inventory control system of multi-product multi-constraint economic order quantity model," *Expert Systems with Applications,* vol. 38, (2011): pp. 2708-2716.

[26] A. R. Nia, M. H. Far and S. T. A. Niaki, "A hybrid genetic and imperialist competitive algorithm for green vendor managed inventory of multi-item multi-constraint EOQ model under shortage," *Applied Soft Computing,* vol. 30, (2015): pp. 353-364.

[27] A. A. Taleizadeh, B. Mohammadi, L. E. Cárdenas-Barrón and H. Samimi, "An EOQ model for perishable product with special sale and shortage," *International Journal of Production Economics,* vol. 145, (2013): pp. 318-338.