Supply Chain and Operations Decision Making

www.scodm.reapress.com

Sup. Chain Oper. Decis. Mak. Vol. 1, No. 1 (2024) 1–6.

Paper Type: Original Article

A Short Review of EOQ Models and Fuzzy Theory in Inventory Management

Ankit Dubey[1,*], Ranjan Kumar[1]

[1] VIT-AP University, Inavolu, Beside AP Secretariat, Amaravati AP, India. Ankitd.vit22@gmail.com; ranjan.kumar@vitap.ac.in.

Citation:

Received: 10 May 2024 *Revised: 16 July 2024* *Accepted: 1 August 2024*	Dubey,A., & Kumar, R. (2024). A short review of eoq models and fuzzy theory in inventory management. *Supply chain and operations decision making, 1*(1), 1-6.

Abstract

In our manuscript, we investigate diverse approaches and methodologies proposed by researchers and scientists. Our analysis encompasses supply chain management, vendor management, and healthcare systems. Specifically, we delve into Economic Order Quantity (EOQ) within IM, exploring its implications. Additionally, we aim to present literature on fuzzy theory, including discussions about triangular and trapezoidal fuzzy sets. Recognizing that classical theory grapples with uncertainty, we underscore the significance of comprehending fuzzy theory through relevant scholarly works.

Keywords: EOQ, SCM, IM.

1 | Introduction

During WW-II from 1939 to 1945, the Operational Research (OR) emanated as a response to the urgent need for managing scarce resources. Analytical methods are used by OR to design, analyze, and enhance systems and processes across various areas, such as transportation, logistics, manufacturing [1], and finance [2].

The goal is to optimize effectiveness, reduce costs, and enhance comprehensive effectiveness by employing mathematical models and algorithms. In the words of Stafford Beer [3], OR applies scientific methods to address challenges in managing large systems involving people, machines, materials, and finances in industry, defense, business, and government. In recent years, several studies have explored various aspects of inventory control, linear programming, and project management under uncertain conditions. Dubey and Kumar [4] reviewed the extended uncertainty principle for inventory control, while Tripathi and Kumar [5] focused on Neutrosophic Linear Programming Problems (LPP). Miriyala and Kumar [6] conducted a state-of-the-art review of critical path methods and project evaluation techniques. Additionally, Navya and Kumar [7]

Corresponding Author: Ankitd.vit22@gmail.com

discussed trends in inventory management and Tripathi and Kumar [8] introduced a short literature on LPP. Looking ahead, Tripathi et al. [9] investigated Neutrosophic LP in advanced fuzzy contexts, and Miriyala et al. [10] explored Neutrosophic critical path problems. Furthermore, Miriyala and Kumar [11] enhanced critical path analysis using Python in Neutrosophic environments, while Dubey and Kumar [12] examined inventory models with sensitivity analysis. Moreover, Miriyala and Kumar [13] discussed enhancing critical path problem in Neutrosophic Environment Using Python. Lastly, Tripathi and Kumar [14] addressed Neutrosophic minimal cost flow problems through multi-objective linear programming.

Moreover, we have investigated various substantial contributions to OR, briefly summarized in *Table 1*.

Table 1. According to different researchers, the effect of OR in real-life.

Ref.	Years	Application	Contribution
[15]	2018	Data modeling	Data Envelopment Analysis (DEA) from a neutrosophic perspective.
[16]	2019	Linear programming	Developing a nonlinear approach for neutrosophic linear programming.
[17]	2020	Supplier problem	Selecting suppliers using the fuzzy Analytic Hierarchy Process (AHP) technique and D-Numbers.
[18]	2023	LPP	Solving fuzzy LPP in multiple dimensions.
[19]	2023	SCM	Internet of Things (IoT) in SCM: addressing challenges, exploring opportunities, and implementing best practices.
[20]	2024	Goal programming	Applying the min-max goal programming approach to solve piecewise quadratic fuzzy multi-objective de novo programming problems.
[21]	2024	SCM	A review of multi-criteria analysis techniques for decision-making in renewable energy supply chains.
[22]	2024	Automotive industry	Developing a structural model for a lean and sustainable supply chain using a total quality management approach in the automotive industry.
[23]	2024	Production management	Optimizing decision-making in production, maintenance, repair, and quality planning through agent-based simulation.
[24]	2024	Vendor problem	An interactive compromise programming approach for solving vendor selection problems under fuzziness.

The overall goal of OR is to equip stakeholders with the necessary instruments and particulars for making informed decisions that enhance organizational performance and efficiency. IM constitutes a frequently discussed topic within OR.

Our primary goal in this paper is to understand inventory management. Nowadays, inventory plays a crucial role in our lives, whether it's in our home kitchens or large factories. Whoever manages inventory can achieve profits. But how do we maximize those profits? To answer this, we need to determine the optimal quantity to purchase and when to place orders. Back in 1913, F. W. Harris [25] introduced a model called Economic Order Quantity (EOQ). This model provides a formula for handling order quantities. R. H. Wilson later modified it in 1940 to address costs associated with inventory, such as carrying costs and set-up costs. Inventory control has various applications, including vendor problems [26], healthcare systems [27], service levels [28], blood banks [29], and methods like ABC [30], FIFO [31], and LIFO [32]. We'll explore some of these inventory control challenges in *Table 2*.

In the table above, we observed the contributions made by various authors to inventory models. This highlights the significant role inventory models play in OR. Researchers and authors explore how to maximize profits while minimizing costs and losses within the inventory model. Consequently, we can assert that inventory models have a substantial impact on real-life scenarios. Now, let's delve into the concept of EOQ within the context of inventory management. We'll explore different authors' contributions to EOQ and examine its practical applications.

Table 2. Some authors-contribution to the inventory model in different areas.

Authors	Contribution
[33]	Optimizing spare parts inventory control Using maintenance planning.
[34]	In this study, authors explore the dimensions related to disruptive factors and inventory control using exploratory factor analysis.
[35]	Identifying weaknesses in the inventory control system: insights from accounting postgraduate students
[36]	In this study, author'sauthors explore the mediation effect of inventory control practices on organizational performance within the context of state-funded hospitals.
[37]	Recent advances in spare parts classification and forecasting for inventory control: a comprehensive literature review.
[30]	Creating a fresh mathematical model using ABC analysis for an inventory control problem: A real-world case study.
[38]	Managing demand and controlling inventory for substitutable products.
[39]	A roadmap for deep reinforcement learning in inventory control.
[40]	The comprehensive approach for intelligent order management application provides a framework for optimized sales and inventory control.

2|Recent Trends in IM

In this section, we are discussing recent trends in inventory control models. There are many models in inventory control, such as the supply chain, Economic Production Quantity (EPQ), EOQ, and others. However, we will focus only on the EOQ model. As we know, Harris first introduced the EOQ model. In this section, we will discuss the work done by different researchers related to EOQ. Further details are explained below.

Mandal [41] developed an EOQ model specifically for items that deteriorate over time. The demand for these items follows a cubic pattern, and the model takes into account salvage value and shortages. Samal et al. [42] proposed an EOQ model for inventory systems where inventory levels depend on the current stock, and in this system, no shortages are allowed. Caliskan [43] derived the optimal solution for the EPQ model with planned shortages without using derivatives. Patriarca et al. [44] studied an EOQ inventory model specifically for perishable products, considering uncertainty. Sundararajan et al. [45] explored how delays in payment, shortages, and inflation impact an EOQ model with bivariate demand. Ghai et al. [46] optimized the EOQ model by accounting for reliability-affected demand rates and uncertainty. Sundararajan [47] investigated amount determination in a non-instantaneous decay EOQ model with shortages, inflation, and delayed payments.

3|Conclusion

In our manuscript, we explore various approaches and methodologies proposed by researchers and scientists. Our analysis spans supply chain management, vendor management, and healthcare systems. Specifically, we delve into EOQ within IM and discuss its impact. Additionally, we aim to share literature on fuzzy theory, including discussions about triangular and trapezoidal fuzzy sets. Recognizing that classical theory struggles with uncertainty, we emphasize the importance of understanding fuzzy theory through relevant literature.

Authors' Contribution

The study's conception and design were contributed to by the authors. Material preparation, analysis and discussion of results were done by the authors. All authors have read and approved the manuscript.

Funding

The authors did not receive any funding or support from any organization or institution

Conflict of Interests

The authors whose names are written on this manuscript certify that they have NO affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

Reference

[1] K, S. J. (2006). *Operations research: theory and applications*. MACMILAN Publishers.

[2] Hussein, H. A., Shiker, M. A. K., & Zabiba, M. S. M. (2020). A new revised efficient of vam to find the initial solution for the transportation problem. *Journal of physics: conference series* (p. 12032). IOP Publishing. https://doi.org/10.1088/1742-6596/1591/1/012032

[3] Singh, A., Wiktorsson, M., & Hauge, J. B. (2021). Trends in machine learning to solve problems in logistics. *Procedia cirp*, *103*, 67–72. https://doi.org/10.1016/j.procir.2021.10.010

[4] Dubey, A., & Kumar, R. (2023). Extended uncertainty principle for inventory control: an updated review of environments and applications. *International journal of neutrosophic science*, *21*(4), 8–20. https://doi.org/10.54216/IJNS.210401

[5] Tripathi, S. K., & Kumar, R. (2023). A review of neutrosophic linear programming problems under uncertain environments. *International journal of neutrosophic science*, *21*(4), 94–105. https://doi.org/10.54216/IJNS.210410

[6] Navya Pratyusha, M., & Kumar, R. (2023). Critical path method and project evaluation and review technique under uncertainty:a state-of-art review. *International journal of neutrosophic science*, *21*(3), 143–153. https://doi.org/10.54216/IJNS.210314

[7] Dubey, A., & Kumar, R. (2024). Recent trends and advancements in inventory management. *EAI endorsed transactions on scalable information systems*, *11*(2), 1–5. https://doi.org/10.4108/eetsis.4543

[8] Tripathi, S. K., & Kumar, R. (2023). A short literature on linear programming problem. *EAI endorsed transactions on energy web*, *10*(1), 1–5. https://doi.org/10.4108/ew.4516

[9] Tripathi, S. K., Dey, A., Broumi, S., & Kumar, R. (2024). Exploring neutrosophic linear programming in advanced fuzzy contexts. *Neutrosophic sets and systems*, *66*, 170–184. https://doi.org/10.5281/zenodo.10939251

[10] Pratyusha, N. M., Dey, A., Broumi, S., & Kumar, R. (2024). Critical Path method and project evaluation and review technique: a neutrosophic review. *Neutrosophic sets and systems*, *67*, 135–146. https://doi.org/10.5281/zenodo.11123614

[11] Pratyusha, M. N., & Kumar, R. (2024). Enhancing critical path problemin neutrosophic environment using Python. *CMES - computer modeling in engineering and sciences*, *140*(3), 2957–2976. https://doi.org/10.32604/cmes.2024.051581

[12] Dubey, A., & Kumar, R. (2024). Inventory model with sensitivity analysis under uncertain environment. *Journal of information and optimization sciences*, *45*(4), 1081–1092. https://doi.org/10.47974/jios-1693

[13] Pratyusha, M. N., & Kumar, R. (2024). Solving neutrosophic critical path problem using Python. *Journal of information and optimization sciences*, *45*(4), 897–911. https://doi.org/10.47974/JIOS-1614

[14] Tripathi, S., & Kumar, R. (2024). Solving neutrosophic minimal cost flow problem using multi-objective linear programming problem. *Journal of information and optimization sciences*, *45*, 1093–1104. https://doi.org/10.47974/JIOS-1694

[15] Edalatpanah, S. A. (2018). Neutrosophic perspective on DEA. *Journal of applied research on industrial engineering*, *5*(4), 339–345. https://doi.org/10.22105/jarie.2019.196020.1100

[16] Edalatpanah, S. A. (2019). A nonlinear approach for neutrosophic linear programming. *Journal of applied research on industrial engineering*, *6*(4), 367–373. https://doi.org/10.22105/JARIE.2020.217904.1137

[17] Salimi, P. S., & Edalatpanah, S. A. (2020). Supplier selection using fuzzy AHP method and D-numbers. *Journal of fuzzy extension and applications*, *1*(1), 1–14. https://doi.org/10.22105/jfea.2020.248437.1007

[18] Edalatpanah, S. A. (2023). A paradigm shift in linear programming: an algorithm without artificial variables. *Systemic analytics*, *1*(1), 1–10. https://doi.org/10.31181/sa1120232

[19] Sallam, K., Mohamed, M., & Wagdy Mohamed, A. (2023). Internet of things (IoT) in supply chain management: challenges, opportunities, and best practices. *Sustainable machine intelligence journal*, *2*, 1–3. https://doi.org/10.61185/smij.2023.22103

[20] Khalifa, H. A. E.-W., Edalatpanah, S. A., & Bozanic, D. (2024). On min-max goal programming approach for solving piecewise quadratic fuzzy multi- objective de novo programming problems. *Systemic analytics*, *2*(1), 36–48. https://doi.org/10.31181/sa21202411

[21] Zahedi, M., Naghdi Khanachah, S., & Zahedi, M. (2024). Providing a structural model lean sustainable supply chain with total quality management approech in the automotive industry. *International journal of research in industrial engineering*, *13*(2), 152–165. https://doi.org/10.22105/riej.2022.342951.1312

[22] Nazabadi, M. R., Najafi, E., & Rasinojehdehi, R. (2024). Integrated decision-making in production, maintenance, repair, and quality planning using an agent-based simulation. *Risk assessment and management decisions*, *1*(1), 12–21. https://ramd.reapress.com/journal/article/view/23

[23] Saeedi, S., Mohammadi, M., & Torabi, S. A. (2015). A de novo programming approach for a robust closed-loop supply chain network design under uncertainty: An M/M/1 queueing model. *International journal of industrial engineering computations*, *6*(2), 211–228. https://doi.org/10.5267/j.ijiec.2014.11.002

[24] Harris, F. W. (1990). How many parts to make at once. *Operations research*, *38*(6), 947–950.

[25] Rabbani, M., Rezaei, H., Lashgari, M., & Farrokhi-Asl, H. (2018). Vendor managed inventory control system for deteriorating items using metaheuristic algorithms. *Decision science letters*, *7*(1), 25–38. https://doi.org/10.5267/j.dsl.2017.4.006

[26] Saha, E., & Ray, P. K. (2019). Modelling and analysis of healthcare inventory management systems. *Opsearch*, *56*(4), 1179–1198. https://doi.org/10.1007/s12597-019-00415-x

[27] Jiang, Y., Shi, C., & Shen, S. (2019). Service level constrained inventory systems. *Production and operations management*, *28*(9), 2365–2389. https://doi.org/10.1111/poms.13060

[28] Yadav, A. S., Ahlawat, N., Sharma, N., Swami, A., & Navyata. (2020). Healthcare systems of inventory control for blood bank storage with reliability applications using genetic algorithm. *Advances in mathematics: scientific journal*, *9*(7), 5133–5142. https://doi.org/10.37418/amsj.9.7.80

[29] Abdolazimi, O., Shishebori, D., Goodarzian, F., Ghasemi, P., & Appolloni, A. (2021). Designing a new mathematical model based on ABC analysis for inventory control problem: A real case study. *RAIRO - operations research*, *55*(4), 2309–2335. https://doi.org/10.1051/ro/2021104

[30] Fikri, A., Andika, A., Dava Cahyoga, M. A., & Ratnasari, A. (2020). Implementation of the FIFO Method in the development of inventory applications for agents sinar baru. *Journal of information systems and informatics*, *2*(2), 216–230. https://doi.org/10.33557/journalisi.v2i2.72

[31] Ajay, S. Y., Abid, M., Bansal, S., Tyagi, S. L., & Kumar, T. (2020). Fifo and lifo in green supply chain inventory model of hazardous substance components industry with storage using simulated annealing. *Advances in mathematics: scientific journal*, *9*(7), 5127–5132. https://doi.org/10.37418/amsj.9.7.79

[32] Zhu, S., Jaarsveld, W. van, & Dekker, R. (2020). Spare parts inventory control based on maintenance planning. *Reliability engineering and system safety*, *193*, 106600. https://doi.org/10.1016/j.ress.2019.106600

[33] Rashid Hashmi, A., Aina Amirah, N., Yusof, Y., & Noor Zaliha, T. (2020). Exploring the dimensions using exploratory factor analysis of disruptive factors and inventory control. *The economics and finance letters*, *7*(2), 247–254. https://doi.org/10.18488/journal.29.2020.72.247.254

[34] Ahmed, E. R., Alabdullah, T. T. Y., Ardhani, L., & Putri, E. (2021). The Inventory control system's weaknesses based on the accounting postgraduate students' perspectives. *Jabe (journal of accounting and business education)*, *5*(2), 2528–7281. https://doi.org/10.26675/jabe.v5i2.19312

[35] Hashmi, A. R., Amirah, N. A., Yusof, Y., & Zaliha, T. N. (2021). Mediation of inventory control practices in proficiency and organizational performance: state-funded hospital perspective. *Uncertain supply chain management*, *9*(1), 89–98. https://doi.org/10.5267/j.uscm.2020.11.006

[36] Bhalla, S., Alfnes, E., Hvolby, H. H., & Sgarbossa, F. (2021). Advances in spare parts classification and forecasting for inventory control: A literature review. *IFAC-papersonline*, *54*(1), 982–987. https://doi.org/10.1016/j.ifacol.2021.08.118

[37] Song, J.-S. J., Xue, Z., & Shen, X. (2021). Demand management and inventory control for substitutable products. *SSRN electronic journal*, *12*, 1–44. https://doi.org/10.2139/ssrn.3866775

[38] Boute, R. N., Gijsbrechts, J., van Jaarsveld, W., & Vanvuchelen, N. (2022). Deep reinforcement learning for inventory control: A roadmap. *European journal of operational research*, *298*(2), 401–412. https://doi.org/10.1016/j.ejor.2021.07.016

[39] Mittal, S. (2024). Framework for optimized sales and inventory control: a comprehensive approach for intelligent order management application. *International journal of computer trends and technology*, *72*(3), 61–65. https://doi.org/10.14445/22312803/ijctt-v72i3p109

[40] Mandal, D. B. (2020). An inventory model for time-varying deteriorating items and weibull distributed ameliorating items with cubic demand under salvage value and shortages. *International journal for research in applied science and engineering technology*, *8*(11), 307–315. https://doi.org/10.22214/ijraset.2020.32126

[41] Samal, D., Mishra, M. R., & Kalam, A. (2022). An EOQ model for Inventory System dependent upon on hand inventory without shortages. *Journal of integrated science and technology*, *10*(3), 193–197.

[42] Çalışkan, C. (2022). Derivation of the optimal solution for the economic production quantity model with planned shortages without derivatives. *Modelling*, *3*(1), 54–69. https://doi.org/10.3390/modelling3010004

[43] Patriarca, R., Di Gravio, G., Costantino, F., & Tronci, M. (2020). EOQ inventory model for perishable products under uncertainty. *Production engineering*, *14*(5–6), 601–612. https://doi.org/10.1007/s11740-020-00986-5

[44] Sundararajan, R., Vaithyasubramanian, S., & Nagarajan, A. (2021). Impact of delay in payment, shortage and inflation on an EOQ model with bivariate demand. *Journal of management analytics*, *8*(2), 267–294. https://doi.org/10.1080/23270012.2020.1811165

[45] Ghai, S., Chauhan, A., & Singh, M. P. (2020). Optimization of the EOQ model with reliability affected demand rate and uncertainty. *International journal of management (IJM)*, *11*(7). https://doi.org/10.34218/IJM.11.7.2020.153

[46] Sundararajan, R., Vaithyasubramanian, S., & Rajinikannan, M. (2022). Price determination of a non-instantaneous deteriorating EOQ model with shortage and inflation under delay in payment. *International journal of systems science: operations and logistics*, *9*(3), 384–404. https://doi.org/10.1080/23302674.2021.1905908