ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Research Article *Araştırma Makalesi* DOI: 10.16951/trendbusecon.1494826

A Review on The Use of Artificial Intelligence and Machine Learning Technologies in The Logistics Sector

Yapay Zekâ ve Makine Öğrenimi Teknolojilerinin Lojistik Sektöründe Kullanımına Yönelik Bir İnceleme

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ABSTRACT

In recent years, developments in Artificial Intelligence (AI) and MachineLearning (ML) technologies have had profound effects on all sectors. The logistics industry has also become a sector where these technologies are being used to a significant extent. The emergence of intelligent logistics systems offers several opportunities for the advancement of this sector by facilitating digital transformation in supply chain and logistics. The aim of this study is to provide a comprehensive review of recent studies examining the use of AI and ML systems in the logistics industry. In this study, which is designed as a systematic study, firstly, based on the existing literature, the basic concepts, trends, researchers and countries working on AI and ML systems in the logistics sector are examined by bibliometric analysis method. Then, information about the prominent AI and ML systems in logistics is given. It is seen that the most frequently used AI and ML technologies in logistics are Deep Learning, Optimization, Internet of Things (IoT), Data Mining and Predictive Models. The methodologies presented in the study have a practical importance in increasing efficiency, transparency and planning in the logistics.

JEL Codes: N70, O14, O33

Keywords: Logistics, Artificial Intelligence, Machine Learning, Technology, Bibliometric Analysis

ÖZ

Son yıllarda yapay zekâ ve makine öğrenimi teknolojilerindeki gelişmelerin tüm sektörlerde derin etkileri bulunmaktadır. Lojistik sektörü de bu teknolojilerin önemli ölçüde kullanıldığı bir sektör haline gelmiştir. Akıllı lojistik sistemlerinin ortaya çıkışı, tedarik zinciri ve lojistik alanında dijital dönüşümü kolaylaştırmasıyla bu sektörün ilerlemesi için çeşitli fırsatlar sunmaktadır. Bu çalışmanın amacı lojistik sektöründe yapay zekâ ve makine öğrenimi sistemlerinin kullanımını inceleyen güncel çalışmaları kapsamlı bir şekilde incelemektir. Sistematik bir çalışma olarak tasarlanan bu çalışmada öncelikle mevcut literatürden yola çıkılarak lojistik sektöründe yapay zekâ ve makine öğrenimi sistemleri ile ilgili temel kavramlar, eğilimler, bu konuda çalışma yapan araştırmacılar ve ülkeler bibliyometrik analiz yöntemiyle incelenmiştir. Daha sonra lojistikte öne çıkan yapay zekâ ve makine öğrenimi sistemleri ile ilgili bilgilere yer verilmiştir. Lojistikte en sık kullanılan yapay zeka ve makine öğrenimi teknolojilerinin derin öğrenme, optimizasyon, nesnelerin interneti, veri madenciliği ve tahmin modelleri olduğu görülmektedir. Çalışmada sunulan metodolojiler lojistikte verimliliği, şeffaflığı ve planlanmayı arttırmada pratik bir öneme sahiptir.

JEL Kodları: N70, O14, O33

Anahtar Kelimeler: Lojistik, Yapay Zekâ, Makine Öğrenimi, Teknoloji, Bibliyometrik Analiz

Introduction

The progress in information technologies is crucial for enhancing the management, execution, and regulation of the movement and retention of goods, services, and data from their source to their destination, with the aim of enhancing consumer contentment (Rejeb et al., 2020, p. 2). The fourth industrial revolution, referred to as Industry 4.0, encompasses a range of concepts and technologies aimed at enhancing the competitive advantage of industrial firms. These concepts include interconnection, digitalization, and automation. Artificial Intelligence (AI) is widely recognized as a crucial facilitator for smart logistics and smart manufacturing endeavors inside this particular framework (Woschank, 2020, p. 1). AI is a broad discipline that encompasses various subfields, including Machine Learning (ML) and Deep Learning. ML, a subfield of AI, is concerned with the development of algorithms that enable computers to extract knowledge from data (Boujarra et al., 2024, p. 1593).

Today, there is significant interest among researchers in logistics and supply chain management to understand the implications and advantages of this field. This interest extends beyond the researchers' own research areas and encompasses emerging technologies and innovations, including AI, Blockchain, metadata, robotics and robotic process automation (Cheah et al., 2023, p. 709). On the other hand, the advent of the internet, advancements in technology, the widespread utilization of information and communication devices by individuals, and the exponential growth of data have presented novel complexities and prospects for transportation and logistics systems (Speranza, 2018, p. 30). For these reasons, there is an urgent need for logistics processes that prioritizes precision, efficiency and adaptability at a time of significant expansion in freight transportation worldwide (Che et al., 2023, p. 36). Efficient and adaptive processes optimize inventory management, reducing costs and delivery times. Adaptability, on the other hand, enables rapid response to changes in demand and gains competitiveness.

**This study was partially presented at the 12th National Logistics and Supply Chain Congress held on November 16-17, 2023 and published electronically as an abstract.*

Geliş Tarihi/Received 03.06.2024
Kabul Tarihi/Accepted 19.07.2024
Yayın Tarihi/Publication Date 15.10.2024

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Cite this article: Oğuz, S. & Yalçıntaş, D. (2024). A Review on The Use of Artificial Intelligence and Machine Learning Technologies in The Logistics Sector *Trends in Business and Economics*, *38*(4), 218-225.

The emergence of intelligent technologies is currently catalyzing a substantial revolution in the field of logistics and transportation. Smart technologies encompass the utilization of AI and data science methodologies, including ML, Big Data, and AI in conjunction with information and communication technologies such as the Internet of Things (IoT) and Blockchain, to generate cognitive awareness of an object. The potential impact of smart technology on enhancing efficiency and effectiveness in logistics operations and transportation systems has been highlighted by Chung (2021, p. 1). Hence, AI and ML techniques are increasingly used in production systems and logistics (Singh et al., 2021, p. 67). The integration of these technologies in logistics aims to increase operational efficiency, meet the increasing need for speed and precision, and radically transform supply chain management. The application of AI and ML methods in logistics leads to beneficial results such as optimizing routes, dynamically managing inventories and making automated decisions. These results replace traditional processes, enabling the adoption of more efficient, adaptive and fast methods to control the flow of goods, services and information from the origin to the final endpoint (Boujarra et al., 2024, p. 1594). It is important to understand the development of these technologies and the state of research in this field in terms of ML and AI. In their study, Song et al. (2021) expressed the technological development stages in logistics from past to present as shown in Table 1.

Table 1 shows that technological development in logistics consists of four stages: logistics mechanization, logistics automation, logistics integration and logistics intelligence. As can be seen from the table, key technologies such as intelligent processing, IoT, AI, Big Data have emerged in logistics from past to present.

Developments in AI and ML technologies have significant impacts on many sectors. The logistics sector is one of the sectors where AI technology has been used extensively in recent years, and the development of intelligent logistics systems offers various opportunities in the development of this sector by promoting digital transformation in the supply chain and logistics sector. The aim of this study is to comprehensively review the existing studies on the use of AI and ML systems in the logistics sector. Analyzing the research on the use of AI and ML in logistics and understanding the developments in this sector is of great importance in supporting the creation of more competitive and efficient logistics operations.

When the literature is examined, it is seen that comprehensive and holistic studies on the logistics applications of these technologies are quite limited. At this point, the findings of this study are expected to contribute to the literature by providing a broad perspective on the integration of AI and ML in logistics processes. On the other hand, the potential of these technologies, which increase efficiency in logistics processes, to reduce energy consumption and minimise carbon emissions is also very valuable in terms of environmental sustainability goals. Therefore, this study is expected to provide guidance to academic researchers and practitioners by presenting the current state of the smart logistics industry in a general framework.

Table 1. *Evolution of Logistics (Song et al., 2021, p. 4253)*

Stage	Mechanization	Automation	Integration	Intelligentization
Term	1920s-1960s	1960s-1990s	1990s-2000s	2000s-now
Characteristics	Mechanical equipment replaces manpower	Automation of equipment and facilities for logistics operations	Multi-system collaboration	Intelligent processing, analysis, decision making
Key Technology	Mechanical manufacturing	Sensor, bar code, automatic control, computer technology	RFID, Internet, communication technology	IoT, AI, Big Data
Example	Truck tractor, Forklift, etc.	Automatic Guided Vehicle, etc.	Logistics information management system, etc.	Unmanned aerial vehicle, automatic delivery robot, etc.

Material and Methods

The present investigation utilized 'VOSviewer', a software application designed for the purpose of constructing, evaluating, and illustrating bibliometric networks. Bibliometric analysis is a method that involves the examination of bibliographic content in an objective and quantitative manner. This approach facilitates the categorization of data within a designated thematic domain. Additionally, it is a method of analyzing scientific publications that assesses advancements in a certain field and the influence of research (Daim et al., 2006; Merigo et al., 2015). The aforementioned approach provides a visual representation of the hierarchical arrangement of the most productive authors, journals, research sub-topics, and nations, hence facilitating an assessment of the present state and future directions within the research domain (Szpilko & Ejdys, 2022, p. 14; Çetiner, 2024, p. 280).

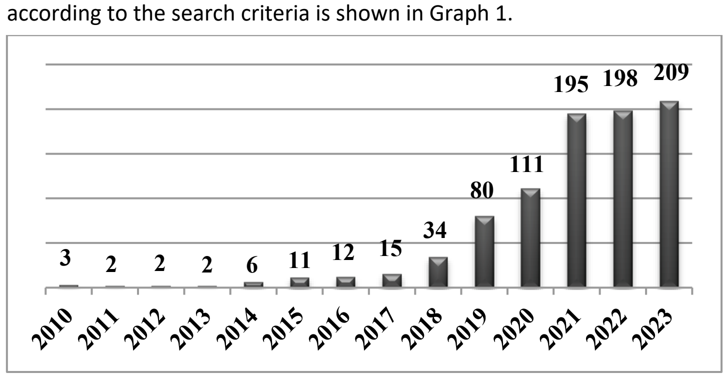
Table 2. Search criteria in Web of Science database

Category	**Search Criteria**
Keywords	Logistics, artificial intelligence, machine learning
Search string	Topic "logistics" AND "artifical intelligence" OR "machine learning"
Types of documents	Article, Proceeding Paper, Book and book chapter
Time range	2010-2023
Language	English

Within the scope of the analysis, the Web of Science database was searched on March 3, 2024 according to the criteria in Table 2. In the second stage, some basic figures on the number, type and index of the publications obtained according to the specified criteria were presented. Then, the distribution of keywords, countries with the most publications, researchers and journals were visualized. Then, the most cited researchers, countries and journals are discussed. In the last section, definitions of the most frequently used keywords related to AI and ML systems in logistics are given.

Results

The distribution of 880 studies published between 2010 and 2023 according to the search criteria is shown in Graph 1.



Graph 1. *Number of publications by years*

When Graph 1 is analyzed, it is seen that there were very few studies on this subject until 2014. In 2015, the number of publications increased from single digits to double digits, and the number of publications has gradually increased since 2018. In 2018, the number of publications doubled compared to the previous year. In 2019, the number of publications increased more than twice the number of publications in 2018 compared to the previous year. Another big increase occurred in 2021. In 2020, with the global Covid-19 pandemic, the importance of technology has increased and all systems have closely experienced online or hybrid systems. In this context, topics such as AI and ML have gained importance in the field of logistics as in all fields.

Table 3 shows the distribution of publications according to their types and indexes. In terms of type, it was seen that most of the publications were articles (601). In terms of index, it was seen that most of the studies (513) were indexed in the Science Citation Index Expanded (SCI-E) index.

Table 3. *Distribution of Publications According to Types and Indexes*

Type	Number of publications
Article	601
Proceeding Paper	222
Book and Book Chapter	57
Web of Science Indexes	
Science Citation Index Expanded (SCI-E)	513
Social Sciences Citation Index (SSCI)	142
Conference Proceedings Citation Index – Science (CPCI –S)	216
Emerging Sources Citation Index (ESCI)	97
Book Citation Index	8

Keywords are used to reflect the primary content of the study subjects in bibliometric analysis. The analysis covered a total of 1360 keywords in the papers examined in this study. Figure 1 illustrates the keywords and clusters of keywords.

Terms that exhibit a robust correlation are grouped together and displayed in the same hue. A minimal spatial separation between phrases signifies their proximity, implying that the words are typically present within the same article abstracts and titles (Yalçıntaş et al., 2023, p. 5). When the distribution of keywords in the studies included in the scope of the analysis in Figure 1 is examined, it is observed that there are 104 keywords used at least five times. The most frequently used keywords were "machine learning", which was used 410 times. The second most used keyword was "logistics", which was used 125 times, while "artifical intelligence", which was used 48 times, ranked third.

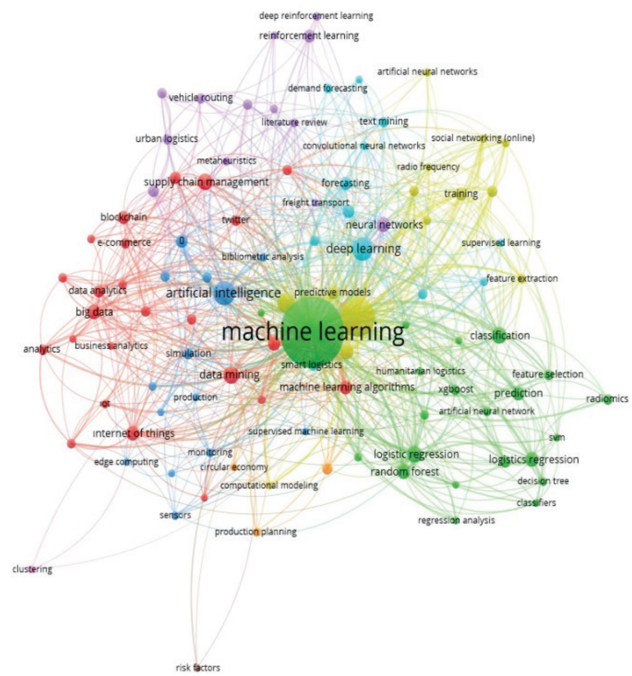


Figure 1. *Keywords*

Table 4 shows the keywords used and the number of keywords used for AI and ML systems in logistics.

Table 4. Keywords Used for AI and ML Systems in Logistics

Keywords	Number of uses
Deep Learning	45
Optimization	29
Internet of Things	26
Data Mining	23
Predictive Models	18

When Table 4 is examined, it is seen that the keywords Deep Learning, Optimization, Data Mining Internet of Things and Predictive Models stand out in studies on AI and ML systems in logistics. Information on these concepts and their use in the field of logistics is provided in the section 2.2. AI and ML Systems in Logistics. The countries with the highest number of publications on the subject are shown in Figure 2.

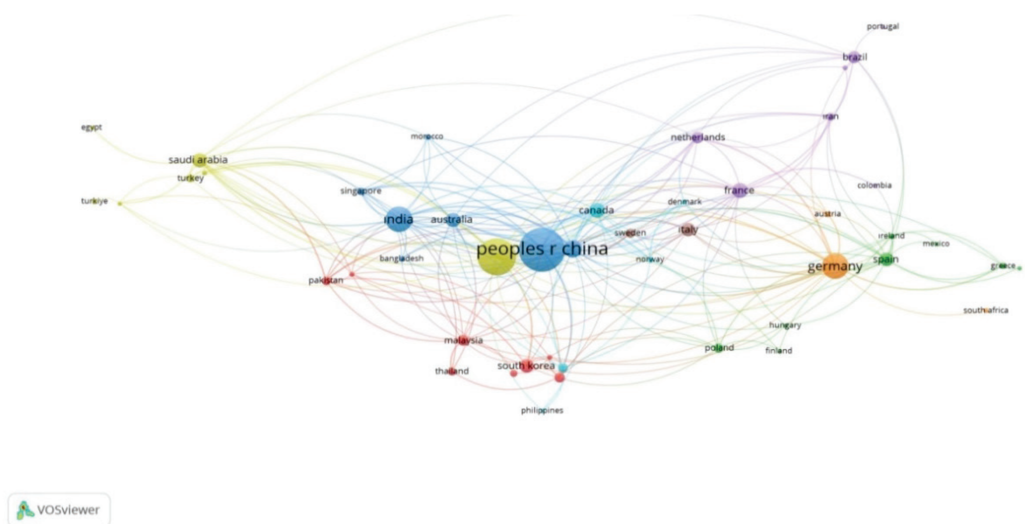


Figure 2. *Countries with the Most Publications*

Figure 2 shows the countries with the highest number of publications on AI and ML systems in logistics. In the publications analyzed within the scope of the analysis, a total of 47 countries are included, provided that there are at least five publications. Among these countries, it is seen that China (203 publications) has the highest number of publications using related concepts. China is followed by the USA (151 publications) and Germany (86 publications).

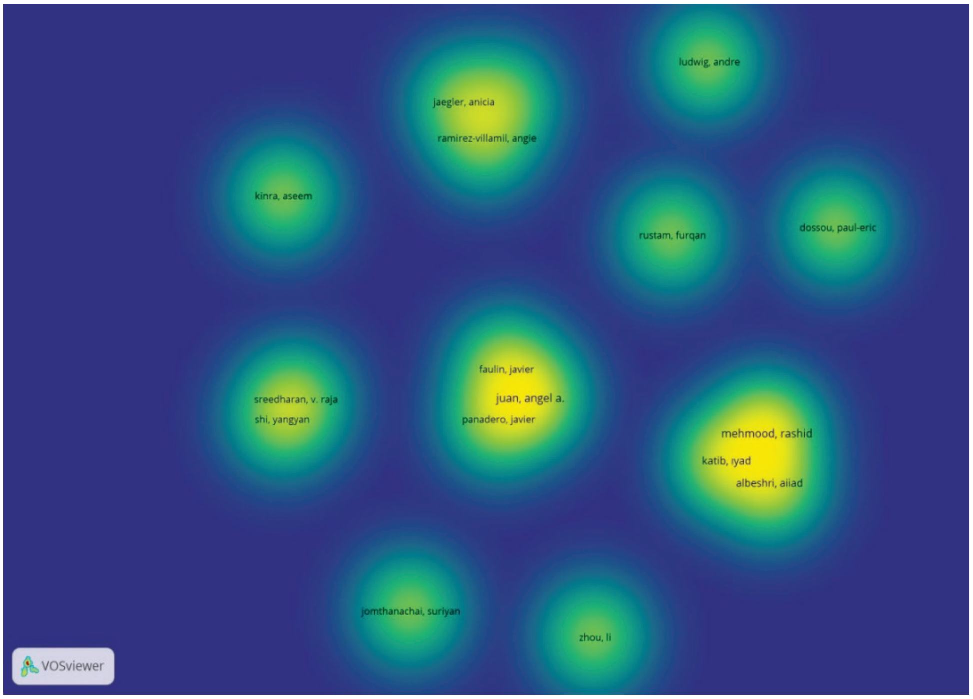


Figure 3. *Researchers with the Most Publications and Co-authorship*

Figure 3 illustrates the researchers who have demonstrated the highest frequency of publications and co-authorships pertaining to the field of AI and ML systems in the domain of logistics. In the context of the analysis, it was observed that a total of 17 researchers had a minimum of three publications. It is seen that the researcher with the highest number of publications and co-authorship on the subject is Rashid Mehmood (7 publications). Angel A. Juan (6 publications) ranks second and Aiiad Albeshri (5 publications) ranks third. The most cited researchers and the number of citations are as shown in Table 5.

When Table 5 is examined, it is seen that Rashid Mehmood (166 citations) is the most cited author in the studies on the research topic. Aiiad Albeshri (136 citations) ranks second and Iyad Katib (132 citations) ranks third.

The number of citations received by the countries where publications on the subject are made is shown in Figure 4.

Table 5. *Most Cited Researchers*

Author Name	Number of Citations
Rashid Mehmood	166
Aiiad Albeshri	136
Iyad Katib	132
Furqan Rustam	94
Angel A. Juan	89
Javier Faulin	58
Aseem Kinra	55
Raja Sreedharan	53
Andre Ludwig	45
Yangyan Shi	35

Figure 4 shows the most cited countries among 47 contries in total with at least five publications and citations. In this context, the most cited country is the USA (2878 citations) followed by France (1999) and China (1654 citations). There are also clusters and links between countries. Table 6 shows the 10 journals with the highest number of publications.

Table 6. *Most Published and Cited Journals*

Journal Name	Number of Publications	Number of Citations
IEEE Access	50	529
Applied Sciences Basel	20	143
Sustainability	16	198
International Journal of Production Research	15	331
Expert Systems with Applications	13	111
Sensors	12	109
IFAC-PapersOnLine	11	45
Neural Computing & Applications	9	66
Annals of Operations Research	8	87
Computers & Industrial Engineering	7	131

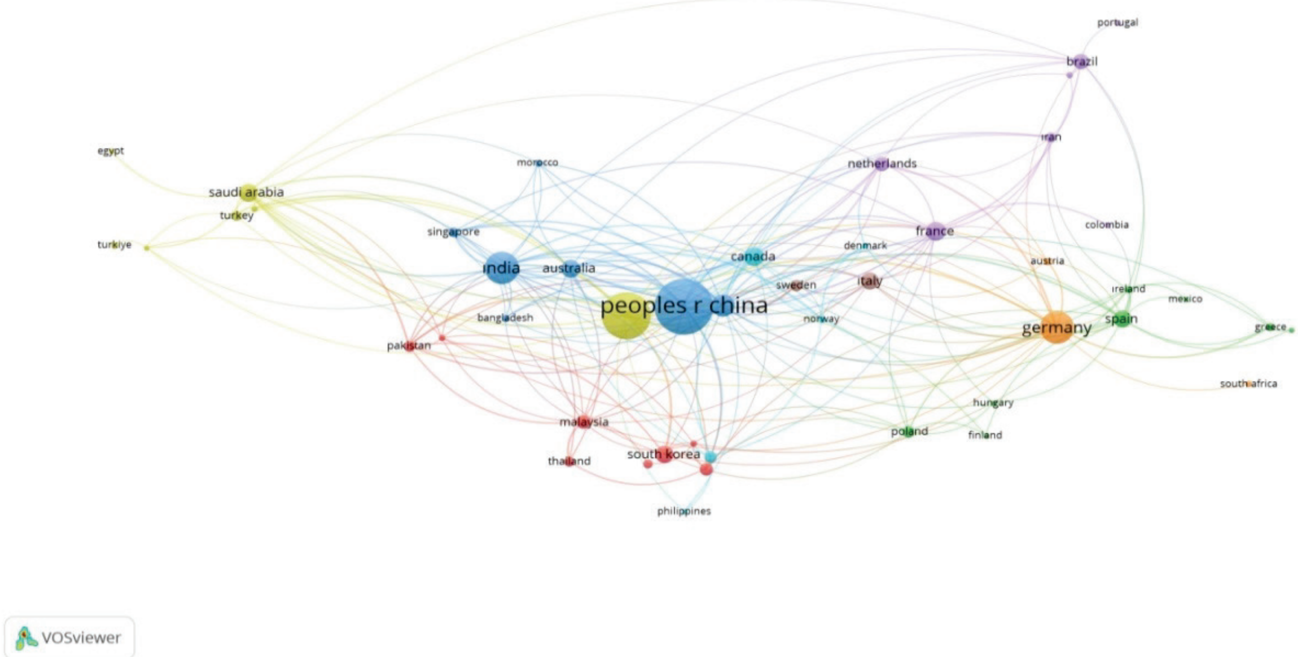


Figure 4. *Most Cited Countries*

Table 6 shows that IEEE Access is the journal with the highest number of publications with 50 publications (529 citations). Applied Sciences Basel ranks second with 20 publications (143 citations). Sustainability journal ranks third with 16 publications (198 citations).

AI and ML Systems in Logistics

Today, the logistics industry faces increasingly complex demand and supply chain dynamics. AI and ML systems are increasingly used in the logistics industry to improve processes, make them more efficient and gain competitive advantage. By using these technologies, businesses can improve their forecasting capabilities, increase operational efficiency and strengthen strategic decision-making processes. In this section, information on AI and ML systems in logistics as indicated in Table 4 is provided.

Deep Learning

With increasing globalization, the logistics industry is becoming more competitive in terms of speed, efficiency and precision. There is a growing demand for technical developments driven by the necessity for streamlined and dependable logistics operations, driven by the requirements of both consumers and companies. Within this particular framework, Deep Learning is acknowledged as a groundbreaking and transformative approach that possesses the potential to significantly alter the manner in which supply chains are effectively administered (Boujarra et al., 2024, p. 1593). The fields of ML and Deep Learning have shown significant growth and widespread adoption in recent years. Both methodologies entail the utilization of algorithms to acquire knowledge from data with the aim of enhancing the precision and effectiveness of forecasts or choices. ML commonly uses statistical techniques for data-driven learning, but Deep Learning leverages neural networks to acquire knowledge from extensive datasets (Sharifani & Amini, 2023, p. 3897).

Deep Learning is defined as a subclass of ML within AI technologies that explores multiple layers of nonlinear information processing for pattern analysis and classification with supervised or unsupervised feature extraction and transformation (Woschank et al., 2020, p. 2). Deep Learning methods are representation-learning methods with multiple levels of representation achieved by building simple but non-linear modules starting from raw input, each of which transforms a representation at one level into a representation at a higher, slightly more abstract level (LeCun et al., 2015, p. 436). In addition to its status as a technological innovation, Deep Learning has the capacity to function as an important catalyst for transformation, offering new insights to overcome the operational and strategic challenges faced by logistics organizations (Boujarra et al., 2024, p. 1594). Therefore, Deep Learning is an increasingly popular technology that provides solutions to today's logistics challenges through the use of advanced data processing skills and ML techniques.

Optimization

Optimization is the use of mathematical or computational methods to optimize a system, process or design. This technology involves improving the system, process or design in order to achieve certain goals such as high profit, lowest cost, and highest efficiency (Mei & Wang, 2021, p. 2). The utilization of optimization modeling has emerged as a potent approach for addressing emergency logistics challenges, particularly in the context of maritime disaster scenarios during the 1970s (Caunhye et al., 2012, p. 4). Following the creation of initial optimization models, operational research has made a substantial contribution to enhancing the efficiency of transportation networks and enabling enterprises facing intricate transportation and logistics challenges to remain competitive (Speranza, 2018, p. 830). Optimization is crucial to meet the demands in logistics. Optimization based on a higher degree of automation in logistics can be more easily achieved by providing and sharing relevant information through Internet of Things systems, creating a level of Logistics 4.0 connected logistics network (Yılmaz & Kuvat, 2021, p. 751). That is, the goal of optimization in the logistics sector is to reduce expenses and increase operational efficiency through the optimal use of corporate resources. This facilitates the formulation of strategic decisions in areas such as demand forecasting, inventory control, routing and delivery scheduling.

Transportation systems are continuously encountering several changes and problems due to the advent of new technology, as they endeavor to offer more cost-effective, efficient, and environmentally friendly services. The primary obstacles involve managing and enhancing the rapid growth of urban traffic to mitigate congestion and traffic volatility, minimize the occurrence of accidents, human fatalities, and property destruction, and enhance the safety and security of both drivers and passengers (Guerrero-Ibañez et al., 2021, p. 1). When it comes to intelligent transportation systems, one of the topics of most interest is route optimization. This system also supports energy efficiency in transportation. For example, instead of lights that are always on in traffic, it encourages systems with the ability to detect and operate appropriately (Jiang et al., 2022, p. 11877). Warehouse space optimization, which includes product layout planning, is also one of the prominent optimizations in logistics (Song et al., 2021, p. 4262). As a result, it can be said that the application of optimization procedures in complex and challenging logistics networks increases operational efficiency, supports sustainability, increases customer satisfaction, and provides competitive advantage.

Internet of Things (IoT)

The progressive character of the Internet in its wide range of uses contributes to the personal, social and economic development of society through the dissemination of statistics, awareness and factual information (Abosuliman & Almagrabi, 2021, p 1). The number of IoT devices interconnected within Internet technology and cyber-physical infrastructure systems is increasing (Savic et al., 2021, p. 59406). Smart logistics is an application and research point of AI and is based on IoT. At this point, IoT-based key technologies play an important role in activities such as optimizing according to changing user needs and improving the user experience (Lu & Han, 2020, p. 6).

IoT is a new concept that covers a wide range of tangible objects. It is predicted to be one of the most widespread modern technologies enabling data connectivity between multiple users in any location. IoT facilitates the communication and sharing of data, enabling more efficient decision-making processes. This technology offers significant adaptability in overcoming the challenges faced in the logistics sector, as well as improving the visibility and responsiveness of this sector (Jiang et al., 2022, p. 11874).

IoT facilitates the interconnection of a large number of devices, objects and individuals with few resources, using the Internet protocol to enable widespread data exchange. Logistics is recognized as an important participant in this goal, aiming to achieve full visibility and transparency by using interconnectivity to collect reliable and secure real-time data (Speranza, 2018, p. 831; Tran-Dang et al., 2022, p. 93). At this point, the adoption and proliferation of IoT devices meets the supply chain's demand for collecting and processing data on changing business environments (Koot et al., 2021, p. 2). This technology facilitates continuous monitoring and tracking of various activities in real time, including inventory management, transportation tracking, and warehouse optimization. IoT increases the efficiency and transparency of logistics networks, leading to reduced costs, improved delivery operations and increased customer satisfaction.

Data Mining

Companies have been urged to embrace data-driven techniques as a result of technological developments in supply chain management and the fact that supply chain networks are experiencing an information overflow. For the time being, data mining employs analytical approaches in order to arrive at conclusions that are both informed and timely. For the purpose of detecting supply chain risk variables, understanding their sources, projecting their impacts, and comprehending the relationships between them, data mining is a vital tool (Kara et al., 2020, p. 1; Ranjan & Bhatnagar, 2011, p. 131). According to Vikram et al. (2011, p. 32) data mining is the act of examining data from a variety of viewpoints and subsequently summarizing it into information that can be utilized for positive purposes (for example, information that may be used to boost revenues, reduce costs, etc.). Furthermore, it is vital for the decision-making process in contemporary logistics management, as it aids in enhancing decision efficiency, defining optimal sales strategies, reducing inventory expenses, and assessing market dynamics and trends.

Data mining techniques and statistical models are employed to analyze information pertaining to the seasons of goods, transportation quantities, stockpiles, and types of goods. This analysis aids in predicting product risk and facilitating decision-making in logistics operational management. Hence, data mining has the capacity to provide significant assistance to the management of contemporary logistics (Cogna et al., 2009, p. 433). Data mining is utilized in diverse domains, including the enhancement of logistics operations, demand forecasting, inventory management, and consumer contact management. This technology is crucial in facilitating firms to achieve a competitive edge by minimizing expenses, enhancing operational effectiveness, and fortifying decision-making processes.

Predictive Models

In recent years, there has been a notable emergence of applications that align with the increasing interest in intelligent transportation systems. The aforementioned applications possess the capacity to enhance transportation by enhancing safety, efficiency, and overall enjoyment. Nevertheless, the development of a precise and effective forecasting system is vital in order to actualize these applications (Boukerche & Wang, 2020, p. 1). Predictive modeling refers to the systematic application of statistical models or data mining algorithms to datasets with the aim of forecasting forthcoming or novel findings. The utilization of modeling techniques enables researchers to elucidate novel associations and mechanisms that underlie intricate patterns, as well as to assess and compare various ideas (Shmueli, 2010, p. 291). The utilization of predictive models in business applications can offer valuable assistance in decision-making processes. These models enable the validation of recommendations regarding the predictive capacity of management operations (Chin et al. 2020, p. 2162).

In the logistics sector, predictive models are used in various fields. This technology provides an effective tool to predict traffic flow, average fuel consumption for trucks and drivers, identify key factors affecting fuel consumption of vehicles (Muchova et al., 2017, p. 161), monitor and manage the safety and quality of perishable food along the supply chain (Tamplin, 2018, p. 90). Moreover, these forecasts support more efficient inventory management and adaptation to changes in demand. Therefore, forecasting models play an important role in facilitating decision-making in strategic planning processes, increasing competitiveness and optimizing operational efficiency.

Conclusion and Recommendations

AI and ML technologies and the development and changes caused by these technologies have had significant impacts on many sectors. These technologies are becoming increasingly important in the logistics industry to improve processes, adaptability, increase efficiency and gain competitive advantage. Intelligent logistics systems are a driving force for the advancement of this sector by enabling digital transformation in supply chain and logistics. The aim of this study is to comprehensively review existing studies focusing on the use of AI and ML systems in the logistics industry. In this context, the study is designed as a systematic study that examines the main concepts, trends, researchers, countries, and lists the most published academic journals and citations related to AI and ML systems in the logistics industry. Within this framework, it is aimed to find and evaluate the relevant literature by using search strings, grouping keywords and within a citation database. The research topic, i.e. conceptual boundaries, was defined based on the term logistics, AI and ML. Then, some basic information about the distribution, type and index of the 880 studies obtained as a result of the search by years, the most frequently used keywords, the distribution of the most publishing countries, researchers and journals, and visual maps of the most cited researchers, countries and journals are given.

After the analysis, it is seen that the use of AI and ML technologies in the logistics sector is mainly in the fields of Deep Learning, Optimization, Internet of Things, Data Mining and Predictive Models. Today, the application of concepts such as Deep Learning, Optimization, Internet of Things, Data Mining and Predictive Models to logistics operations is observed through many methodologies and provides important contributions to logistics managers in decision-making studies. Deep Learning has enhanced capabilities to analyze and predict complex data structures, while optimization techniques serve to reduce the costs associated with logistics operations and improve overall efficiency. Similarly, Data Mining and Predictive Modelling can be used to extract key information from historical data sets, predict future patterns and formulate business strategies. IoT increases operational efficiency by facilitating communication between objects and devices in logistics processes and by enabling real-time data collection and analysis. These principles make significant contributions to the field of logistics and play an important role in increasing the sector's competitiveness and formulating more effective strategies for the future.

As a result developments in AI and ML technologies are having a significant impact on the logistics sector. These developments, which make logistics operations more effective, adaptable and competitive, contribute to improving the performance of companies. These systems, which are discussed and summarised in this study, have a practical importance in increasing efficiency, transparency and planning in the logistics sector. In addition, this study is expected to contribute to the development of related technologies in logistics and to provide guidance to researchers working in this area.

Peer-review: Externally peer-reviewed.
Author Contributions: Concept-S.O.; Design- S.O., D.Y.; Supervision- S.O., D.Y.; Resources- S.O., D.Y.; Data Collection and/or Processing- D.Y.; Analysis and/or Interpretation-S.O.; Literature Search-D.Y.; Writing Manuscript- S.O., D.Y.; Critical Review- S.O., D.Y.
Conflict of Interest: The authors have no conflicts of interest to declare.
Financial Disclosure: The authors declared that this study has received no financial support.

Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir-S.O.; Tasarım-S.O., D.Y.; Denetleme-S.O., D.Y.; Kaynaklar- S.O., D.Y.; Veri Toplanması ve/veya İşlemesi- S.O.; Analiz ve/ veya Yorum-S.O.; Literatür Taraması-D.Y.; Yazıyı Yazan- S.O., D.Y.; Eleştirel İnceleme- S.O., D.Y..
Çıkar Çatışması: Yazarlar, çıkar çatışması olmadığını beyan etmiştir.
Finansal Destek: Yazarlar, bu çalışma için finansal destek almadığını beyan etmiştir.

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Genişletilmiş Özet

İnternet, teknolojik gelişmeler, bilgi ve iletişim cihazlarının bireysel kullanımı, büyük miktarda verinin yaygınlaşması, ulaşım ve lojistik sistemleri için yeni zorluklar ve fırsatlar yaratmıştır. Dünya çapında yük taşımacılığında kayda değer bir genişlemenin yaşandığı bu dönemde hassasiyet, verimlilik ve uyarlanabilirliğe öncelik veren lojistik süreçlerine acil ihtiyaç duyulmaktadır. Günümüzde, akıllı teknolojilerin birçok uygulaması, çeşitli lojistik operasyonlarında ve ulaşım sistemlerinde verimliliği ve etkinliği artırmada potansiyel vaat ettiğini göstermiştir. Makine öğrenimi ve yapay zeka teknikleri üretim sistemlerinde giderek daha fazla kullanılmaktadır. Lojistik ve tedarik zinciri yönetimi alanı da makine öğrenimi ve yapay zeka teknolojilerinden etkilenmektedir. Bu teknojilerin gelişimi oldukça dinamik alandaki araştırmaların makine öğrenimi ve yapay zeka açısından ne durumda olduğunu anlamak büyük önem taşımaktadır. Bu çalışmanın amacı, lojistik sektöründe yapay zekâ ve makine öğrenimi sistemlerinin kullanımına odaklanan mevcut çalışmaları kapsamlı bir şekilde incelemektir. Bu kapsamda arama dizeleri kullanarak, anahtar kelimeleri gruplandırarak ve bir atıf veritabanı içinde ilgili literatürü bulmak, seçmek ve değerlendirmek amaçlanmıştır. Bu nedenle, araştırma konusu, yani kavramsal sınırlar, lojistik, yapay zeka ve makine öğrenimi terimleri temel alınarak tanımlanmıştır. Çalışmada bibliyometrik ağları oluşturmak, analiz etmek ve görselleştirmek için bir yazılım aracı olan 'VOS viewer' programından yararlanılmıştır. Analiz kapsamında ilk olarak, 2010-2023 yılları arasında WoS veritabanında İngilizce dilinde yayımlanan ve başlığında “logistics" and "artifical intelligence" or "machine learning” geçen 880 çalışma görselleştirilmiştir. Araştırma, yalnızca yüksek kaliteli çalışmaları dikkate almak için makaleler, konferans bildirileri, kitap ve kitap bölümleri ile sınırlandırılmıştır. 880 yayının yıllara göre dağılımlarında 2018 yılı itibariyle yayın sayısında neredeyse iki kat artış olduğu görülmüştür. 2021 yılına kadar yüksek oranda artışlar devam etmiş; 2021 yılından itibarende yayın sayılarındaki artış oranı azalsa da artan eğim devam etmiştir. İncelenen 880 yayının en fazla (601 adet) makale türünde olduğu ve çoğu çalışmanın (513 tane) Science Citation Index Expanded (SCI-E)’de indekslendiği görülmüştür. İncelenen makalelerdeki toplam 1360 anahtar kelime ile analiz gerçekleştirildiğinde en sık kullanılan anahtar kelimeler 410 kez kullanılan "makine öğrenimi" , 125 kez kullanılan "lojistik", ve 48 kez kullanılan "yapay zeka" olmuştur. Lojistikte yapay zeka ve makine öğrenimi sistemleri hakkında en fazla yayına sahip ülkelerin sırasıyla Çin (203 yayın), ABD (151 yayın) ve Almanya (86 yayın) olmuştur. Konuyla ilgili en fazla yayın ve ortak yazarlığa sahip araştırmacının Rashid Mehmood (7 yayın) olduğu görülmüştür. Angel A. Juan (6 yayın) ikinci sırada, Aiiad Albeshri (5 yayın) üçüncü sırada yer almıştır. En çok atıf alan yazarın Rashid Mehmood (166 atıf) olduğu görülmektedir. Lojistikte yapay zeka ve makine öğrenimi sistemleri konusunda en çok atıf yapılan ülke ABD (2878 atıf) olmuştur. Konuyla ilgili yayın yapan dergiler incelendiğinde IEEE Access'in 50 yayın, 529 atıf ile en fazla yayına sahip dergi olduğu görülmüştür. Son olarak bulgularda, lojistikte yapay zeka ve makine öğrenimi sistemleri üzerine yapılan çalışmalarda Derin Öğrenme, Optimizasyon, Veri Madenciliği Nesnelerin İnterneti ve Tahmine Dayalı Modeller anahtar kelimelerinin öne çıktığı görülmektedir. Çalışmanın son kısmında analiz sonuçlarına dayalı olarak lojistikte yapay zekâ ve makine öğrenimi sistemlerine dair en sık kullanılan kullanılan anahtar kelimeler (derin öğrenme, optimizasyon, nesnelerin interneti, veri madenciliği ve tahmine dayalı modelleme) ile ilgili tanımlamalara yer verilmiştir.