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ARTIFICIAL INTELLIGENCE INTEGRATION OF LARGE LOGISTICS COMPANIES

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Abstract:
In the digital world with a focus on customer experience, the journey that begins in the virtual realm is completed with a positive impact when it turns into a physical experience, thanks to successful operations in logistics processes. The purpose of this article is to systematically examine the integration of artificial intelligence into processes in logistics management within the supply chain, thereby providing a framework for businesses in the industry. The main motivation for the methodology developed through the process-technology alignment in logistics management is derived from existing research in the literature. The seven areas in logistics management identified by Mentzer et al. (2008) serve as the theoretical guiding principles and foundation of this study. Building upon this foundation, the research question of how companies can achieve the integration of artificial intelligence in logistics management domains has been answered.

Keywords:
Logistics, Artificial Intelligence, Integration, Digitalization

1. Introduction

Just 10 years after the emergence of Industry 4.0 in Germany in 2011, a new revolution is underway, primarily driven by artificial intelligence and generative artificial intelligence.

When considering the long years that have passed between industrial revolutions, it seems that the revolutions driven by digitalization, including the upcoming ones, will continue to amaze. Especially in the context of the Covid-19 pandemic, irreversible changes and transformations have occurred in nearly every sector. Along with the pandemic, the rapid advancements in digital technology and tools have profoundly impacted logistics functions. According to a report published by the Statista Research Department in June 2023, the global size of the logistics industry was approximately $10.41 trillion USD in 2022. It is projected that the scale of the logistics industry will exceed $14.08 trillion USD by 2028 (Statista 2023).

Logistics is one of the most critical areas for companies to enhance their process performance and achieve customer satisfaction. In today's world, where competition reaches its peak with digitalization, the concern for customer satisfaction is highly dependent on the speed and quality of logistics services. As a result, artificial intelligence applications are increasingly being utilized to manage logistics chains. These applications contribute to reducing operational costs and storage expenses. In addition to the economic value that artificial intelligence brings, it also enhances the efficiency of the time required to execute logistics operations. In summary, artificial intelligence technologies are more cost-effective in logistics management because they provide reliable, fast, and resilient solutions.

In the article, following the systematic literature review, a detailed examination of logistics processes was conducted. Subsequently, the article is structured to provide a conceptual methodology for artificial intelligence applications used or to be used in logistics processes.

2. Literature

2.1 Areas of Logistics Management

According to Jayaraman and Ross (2003), a supply chain can be defined as a process that synchronizes the flow of physical goods from resource utilization to consumption and provides enhanced customer and economic value through management.

In this study, the use of artificial intelligence technologies in the field of logistics is shaped based on the research conducted by Mentzer et al. (2008), where conceptualizations and breakpoints were identified. Mentzer et al. (2008) investigated the systematic management of logistics functions for effective customer service, total cost efficiency, competitive advantage, and ultimately enhanced organizational performance. According to Mentzer et al. (2008), logistics management encompasses seven areas: (1) Transportation network design and management; (2) Warehousing techniques, including location, design, and management; (3) Materials handling management; (4) System-wide inventory management; (5) Order management and fulfillment; (6) Procurement; and (7) Customer service.

2.1.1. Transportation network design and management

Transport network design is a critical component of transportation planning between the origin and destination, and accessibility is an important indicator for evaluating the quality of transportation networks. This subject continues to be extensively researched in the field of transportation science (Melkote et al., 2001; Tong et al., 2015). Planning, operational efficiency, customer satisfaction, and cost reduction are achieved through the creation of planning, operational, and control models (Owais, 2015). Due to the unique complexity of model formulation, network design problems are considered one of the most challenging issues in transportation (Yang et al., 1998; Tong et al., 2015). The primary goal is to show the user the most advantageous and acceptable development paths for the transportation network; optimization begins here.

2.1.2. Warehousing techniques, including location, design, and management

The selection of locations for distribution centers is among the most critical management decisions. Both the cost of a distribution system and the level of customer service are significantly influenced by the number, size, and location of distribution centers and which customers will be served from each center. (Perl & Daskin, 1985). According to Van den Berg et al. (1999), warehouse management involves planning aspects in warehouses, inventory management, and storage location allocation. Inventory management/production planning determines which products and in what quantities will be stored in the warehouse, while storage location allocation decides where the products will be stored. Intelligent inventory management can lead to a reduction in storage costs.

2.1.3. Materials handling management

In the process of material handling system design, a crucial factor is the selection and configuration of equipment for material transport. Taking into account both human and technical factors is important to enhance the performance of distribution operations and improve the material handling process. Chakravorty (2009) emphasizes the consideration of various elements in material handling management. Firstly, it involves creating a transportation system that encompasses sorting, speed, layout, and routing activities, as well as analyzing the materials to be transported and classifying them based on their physical condition. It is also essential to examine the equipment and devices related to the process (Chakravorty, 2009).

2.1.4. System-wide inventory management

Inventory management is a part of supply chain management that plans, implements, and controls the efficient, effective, forward, and reverse flow and storage of goods, services, and related information between the point of production and the point of consumption to meet customer demands. According to Singh and Verma (2018), the scope of inventory management includes replenishment lead times, inventory carrying costs, asset management, inventory forecasting, inventory valuation, inventory visibility, future inventory price estimation, physical inventory, available physical space, quality management, inventory replenishment, returns, and refunds. The crucial aim is to minimize the inventory investment that balances supply and demand. In their studies, Singh and Verma (2018) anticipate that inventory management issues, such as maintenance policies, transportation costs, holding costs, and ordering costs, will be addressed through performance improvement, system structure enhancement, and technology integration.

2.1.5. Order management and fulfillment

The order fulfillment process begins with the receipt of orders from customers and ends with the delivery of finished products. The order fulfillment cycle time is defined as the time elapsed from order receipt to product delivery. This process, as described by Davenport (1993), typically involves the coordination of various activities across multiple business units, including sales commitment, credit check, production, logistics, accounts receivable, and relationships with external suppliers for procurement or shipping (Lin & Shaw, 1998). Lin and Shaw (1998) summarized the key activities of the order fulfillment process as follows: Order management; involves receiving customer orders and processing order requests. Manufacturing; encompasses production planning, material planning, capacity planning, and shop floor control. Distribution: considers logistics, including inventory and shipping. In summary, it is recommended to achieve the timely fulfillment of customer orders and attain agility to cope with uncertainties (Lin & Shaw, 1998).

2.1.6. Procurement

The evolving context and new demands related to logistics, particularly following developments post the Covid-19 pandemic, trigger the continuous transformation and differentiation of the procurement process in logistics services. These developments increase the complexity of the procurement process in logistics (Andersson & Norrman, 2002). Procurement represents one of the final frontiers for the integration of functions aimed at the full coordination and control of a company's product, production, and logistics activities. In many companies, it operates as an independent function. Traditionally, procurement activities were limited to receiving material requests from user departments and converting them into purchase orders or contractual relationships with suppliers. However, there is a trend toward changing procurement roles, organizations, and reporting relationships (Cavinato, 1992).

2.1.7. Customer service

There is a wealth of research supporting the impact of logistics customer service on business performance. Logistics management is one of the key themes within the supply chain, and logistics customer service stands as one of the most critical touchpoints with the customer. In today's complex supply chain environment, it is increasingly vital for achieving success and competitive advantage. There is a growing belief that new approaches are required for logistics customer relationship research, going beyond generalizable correlations among variables to focus on specific contexts and mechanisms that guide the generation of customer insights and outcomes.

According to Langley and Holcomb (1992), in an effort to recognize the emphasis on providing customers with the "best comparative net value," logistics represents a fundamental bundle of resources that can be successfully applied to this end. Customer value can be created through product availability, timeliness and consistency of delivery, ease of placing orders, and other elements of customer service. The net impact is that logistics services are increasingly being acknowledged as a fundamental element of customer satisfaction in numerous product markets today (Langley and Holcomb, 1992).

2.2. Artificial intelligence

According to Baryannis et al. (2019), artificial intelligence research has a long history since the creation of the Turing Test in 1950 and the conceptualization of the field. Interest in artificial intelligence has shown remarkable variations, from periods of low interest, known as AI winters, to periods of resurgence and rapid progress.

According to Brunette et al. (2009), the field of Artificial Intelligence is generally accepted to have begun with the first use of the phrase "Artificial Intelligence" at a conference held at Dartmouth College in July 1956. Two main approaches have been developed for general AI; the "top-down" approach, which starts with higher-level functions and implements them, and the "bottom-up" approach, which looks at the neuron level and works to build higher-level functions. In 1956, Allen Newell developed "The Logic Theorist," a theorem proving program. Various programs and methodologies were developed in the following years. More recently, with the advent of technologies related to computing and robotics, there has been a broad-based attempt to create embodied intelligences. However, the unique nature of this field has resulted in many initiatives being almost completely disconnected. Due to the

difficulty and failure in building physical robots, there has been a trend towards computer simulation called "Artificial General Intelligence", where virtual agents in the virtual reality world attempt to achieve intelligent behavior.
According to Salehi and Burgueño (2018), artificial intelligence (AI) has proven to be an efficient alternative approach to classical modeling techniques. They also emphasize that AI-based solutions are excellent alternatives for determining engineering design parameters when testing is not possible, resulting in significant savings in terms of human time and effort spent on experiments. Salehi and Burgueño (2018) also point out that AI has the capability to expedite the decision-making process, reduce error rates, and enhance computational efficiency (Salehi & Burgueño,2018).
According to Woschank and Zsifkovits (2020), artificial intelligence, along with its subcategories such as machine learning and deep learning, can be considered one of the most critical success factors in the digital transformation process. In this context, artificial intelligence, particularly, can be defined as the science and engineering of intelligent machines that focus on smart computer programs. Machine learning is regarded as an integral part of AI, which involves the automatic detection of meaningful patterns in datasets. Machine learning tools aim to improve the efficiency of algorithms by enabling learning and adaptation based on big data analytics. Additionally, deep learning is defined as a subclass of AI technologies that explores non-linear information processing layers for supervised and/or unsupervised feature extraction and transformation. It is used for pattern analysis and classification (Woschank & Zsifkovits, 2020).

3. Artificial Intelligence Use of Logistics

Artificial intelligence-based applications have begun to manage processes in a wide range of industries. Innovative solutions related to artificial intelligence are triggering the use of these solutions in processes across various fields, from manufacturing processes to logistics. Industries require support in adopting this new technology and, at the same time, they appear to be quite eager to embrace it in order not to be left behind.
After the Covid-19 pandemic, which took the world by surprise, important lessons were learned from the suddenly disrupted supply chains and the consecutive interruptions in business continuity. New goals have been set to ensure business continuity and efficient, cost-effective operations for logistics processes. To achieve these goals and make processes sustainable, the use of artificial intelligence-based solutions is a priority. Logistics processes must progress towards enhancing the ultimate goal of customer experience with connected and smart technologies. Artificial intelligence innovation is at the heart of all these operations and offers a wide range of solutions to streamline activities.
In their research, Woschank et al. (2020) have identified five clusters that can be amalgamated to form a conceptual framework for the application of AI, ML, and DL in Smart Logistics in industrial enterprises. They have defined these clusters as frameworks for cyber-physical systems in logistics, predictive maintenance, decision support systems and man-machine interaction, production planning and control systems, and improvement of operational processes in logistics. According to the results of content analysis, they have matched relevant methods and tools indicated in the literature with each of the identified clusters. Woschank et al. (2020) have anticipated that a significant amount of data can be used for automatically adapting processes using artificial intelligence and cognitive computing in a cyber-physical process management system, based on the management of cyber-physical processes.
The most fundamental stage within logistic processes is route optimization. Route optimization can be defined as finding the most efficient route by considering various parameters. Simultaneously, the complexity of different transportation modes (air, sea, road) is designed within this process. Reduced distance per unit can also proportionally reduce costs. Successfully optimizing routes is a key focus in gaining a competitive advantage by saving resources from various sources (Xin et al., 2022). According to Xin et al. (2022), a research strategy and the realization of growth are established for optimizing routes, which forms the basis for improving transportation, creating systems managed with modern references, developing professional transportation technology, and offering e-commerce. Advanced artificial intelligence capabilities can make real-time and predictive adjustments to routes. According to ASD Report (2022), the global route optimization software market reached a value of $6.7 billion in 2021. IMARC Group expects the market to reach $17.7 billion by 2027, exhibiting a CAGR of 17.3% during the period 2022-2027 (IMARC Group, 2022).

Fleet management operations, according to Deloitte (2017), encompass the entire lifecycle of a high volume of vehicles, including financing, leasing/purchasing, service optimization, and contract termination. Companies often struggle to efficiently manage their fleets. Artificial intelligence algorithms can be employed in all aspects of fleet management and optimization processes. This enables real-time tracking of all processes, from fuel optimization to vehicle performance.

Andlauer Transportation Services (ATS) is a leading Canadian provider of temperature-controlled healthcare transportation, boasting a network of 23 facilities and a large fleet of vehicles. To ensure compliance with pharmaceutical regulations, ATS partnered with Fleet Complete for a comprehensive fleet management and GPS tracking solution. Each refrigerated vehicle is equipped with MGS 200 fleet tracking devices, integrated with temperature management, alarm notification, and reporting features. These devices monitor goods' temperatures throughout the delivery process, providing real-time data on both the vehicle environment and the actual products. The system sends alarms to ATS headquarters if the truck's back door is opened, ensuring close monitoring of goods' temperatures. All sensor data is recorded and stored for at least seven years, offering pharmaceutical customers valuable insights to guarantee the quality and safety of their products upon arrival at their destinations. Access to on-board information for monitoring and reporting purposes gives ATS a strategic edge in the competitive trucking industry.

In transportation network design and management, particularly, transportation risks and environmental risks should be controlled. Artificial intelligence-supported cameras and sensors can monitor traffic for traffic surveillance and safety, track vehicles in traffic, detect speed, braking, and sharp turns, and identify accidents. This provides support for accident prevention and risk reduction. Predictive maintenance can also eliminate adverse risks by predicting when transportation infrastructure such as roads, bridges, and tunnels along the route will require maintenance or repair. Artificial intelligence is a fundamental dimension for autonomous vehicles used in logistics processes. Environmental impact assessment can be conducted through artificial intelligence. It can be used in transportation to assess its environmental impacts and suggest ways to reduce the carbon footprint.

Maritime software and data services expert NAPA, in collaboration with Norsepower and Sumitomo, conducted a study revealing the potential to reduce carbon dioxide emissions by up to an average of 28% using rotor sails and voyage optimization. The joint simulation project among NAPA, Norsepower, and Sumitomo analyzed the benefits of combining wind propulsion with voyage optimization to deliver maximum emission reduction potential.

4. Artificial Intelligence Integration of Lojistics

The seven areas in logistics management identified by Mentzer et al. (2008) form the theoretical guiding principles and basis of this study. Based on this study, subcomponents of these dimensions were identified in the literature. For these sub-components, matches have been made with artificial intelligence applications that can be integrated. The integration of AI into each subcomponent of these processes is presented in Table 1. Of course, these subcomponents can be further detailed based on different subcategories of artificial intelligence. However, this study aims to present a general framework. A more detailed examination in future studies and a clear definition of areas related to other technologies and their integration will contribute more to the literature.

The dimensions of transportation network design with artificial intelligence can be examined under three main headings, based on the studies conducted by Liu (2021), Mehmood (2021), and Choi, Chiu & Chan (2016): 1) Route Optimization, 2) Fleet Management, and 3) Risk Management. These dimensions can be managed using rule-based AI, predictive maintenance, and predictive analytics processes.

Table 1. Integration of artificial intelligence in logistic processes

Logistics Processes	Processes' Subcategories	Artificial Intelligence Integration
1.Transportation network design *Identified by Mentzer et al. (2008)*	1)Route Optimization 2)Fleet Management 3) Risk Management *Liu, (2021); Mehmood, (2021); Choi, Chiu&Chan (2016).*	Rule-Based AI Predictive Maintenance Predictive Analytics

2.Warehousing techniques, including location, design, and management *Identified by Mentzer et al. (2008)*	1)Inventory Management 2)Layout Optimization 3) Order Management *Babbar&Prasad (1998); Zhang, Kou, Song, Fan, Usman, & Jagota (2022); Bienstock, Royne, Sherrell & Stafford (2008).*	Supervised Learning AI Optimization Algorithms Rule-Based AI, Machine Learning Predictions
3.Materials handling management *Identified by Mentzer et al. (2008)*	1)Equipment Selection 2)Flows of Materials 3)Monitoring System *Mohsen&Hassan (2010); Klingenberg&Boksma (2010); Cordeau,Pasin& Solomon (2006).*	Optimization Algorithms Real-Time Material Flow Tracking Real-Time Monitoring
4.System-wide inventory management *Identified by Mentzer et al. (2008)*	1) Demand Forecasting 2) Inventory/Safety Stock Optimization 3) ABC Analysis *Nuzzolo&Comi (2014); Geunes&Pardalos (2003); Amirkolaii, Baboli, Shahzad& Tonadre (2017); Stojanović&Regodić, (2017).*	Machine Learning Predictions Real-Time Monitoring
5.Order management and fulfillment *Identified by Mentzer et al. (2008)*	1) Order Management 2)Return Management *Gunasekaran& Ngai (2003); Ravi, Shankar& Tiwari (2005); Glenn Richey, Genchev& Daugherty (2005).*	Automated Order Processing Image Recognition for Quality Control Predictive Analytics for Order Delays Robotics for Warehousing Dynamic Pricing Algorithms
6. Procurement *Identified by Mentzer et al. (2008)*	1)Supplier Management 2)Cost Reduction *Prajogo,Chowdhury,Yeung, & Cheng, T. C. E. (2012); Wagner (2006).*	Smart Order Management Risk Analysis and Management Forecasting Algorithms Optimization Algorithms Blockchain Technology
7. Customer service *Identified by Mentzer et al. (2008)*	1)Communication Management 2)Resolution/ Feedback Analysis *Kahnali&Esmaeili (2015); Kersten&Koch (2010);*	Personalization Algorithms Natural Language Processing (NLP) AI (Speech and Text

	Emerson&Grimm (1996).	Analytics) Chatbots for Customer Service RPA (Robotic Process Automation)

The dimensions of warehousing techniques, including location, design, and management (Identified by Mentzer et al., 2008) with artificial intelligence can be examined under three main headings, based on the studies conducted by Babbar&Prasad (1998); Zhang, Kou, Song, Fan, Usman, & Jagota (2022); Bienstock, Royne, Sherrell & Stafford (2008): 1)Inventory Management, 2)Layout Optimization, and 3) Order Management. These dimensions can be managed using supervised learning AI, optimization algorithms,rule-based AI, machine learning predictions.
The dimensions of materials handling management (Identified by Mentzer et al., 2008) with artificial intelligence can be examined under three main headings, based on the studies conducted by Mohsen&Hassan (2010), Klingenberg&Boksma (2010), Cordeau&Pasin& Solomon (2006).: 1)Equipment Selection, 2)Flows of Materials, and 3)Monitoring System. These dimensions can be managed using optimization algorithms, real-time material flow tracking.
The dimensions of System-wide inventory management (Identified by Mentzer et al., 2008) with artificial intelligence can be examined under three main headings, based on the studies conducted by Nuzzolo&Comi (2014); Geunes&Pardalos (2003); Amirkolaii, Baboli, Shahzad& Tonadre (2017); Stojanović&Regodić, (2017).: 1)Demand Forecasting, 2)Inventory/Safety Stock Optimization, and 3)ABC Analysis. These dimensions can be managed using machine learning predictions, real-time monitoring.
The dimensions of order management and fulfillment (Identified by Mentzer et al., 2008) with artificial intelligence can be examined under two main headings, based on the studies conducted by Gunasekaran& Ngai (2003), Ravi, Shankar& Tiwari (2005), Glenn Richey, Genchev& Daugherty (2005): 1) Order Management and 2)Return Management.These dimensions can be managed using automated order processing, image recognition for quality control, predictive analytics for order delays, robotics for warehousing, dynamic pricing algorithms
The dimensions of procurement (Identified by Mentzer et al., 2008) with artificial intelligence can be examined under two main headings, based on the studies conducted by Prajogo, Chowdhury,Yeung, & Cheng, T. C. E. (2012); Wagner (2006): 1)Supplier Management and 2)Cost Reduction. These dimensions can be managed using smart order management, risk analysis and management, forecasting algorithms, optimization algorithms, blockchain technology.
The dimensions of customer service (Identified by Mentzer et al., 2008) with artificial intelligence can be examined under two main headings, based on the studies conducted by Kahnali&Esmaeili (2015); Kersten&Koch (2010); Emerson&Grimm (1996): 1) Communication Management and 2)Resolution/ Feedback Analysis. These dimensions can be managed using personalization algorithms, Natural Language Processing (NLP), AI (speech and text analytics), chatbots for customer service, RPA (Robotic Process Automation)

5. Conclusion

Many researchers in the literature state that the applications of artificial intelligence in logistics processes are still in the development stage. Considering the different levels of development in global logistics applications, time is needed for the use of artificial intelligence to reach the desired maturity level. However, investments and innovative studies in artificial intelligence all over the world are making unexpected developments at a rapid pace. Therefore, it is clear that artificial intelligence will be an important enabler for large logistics companies. Significant progress has been made in main processes such as route optimization, fleet management, inventory management and material flow. In this study, an attempt was made to create a general framework for artificial intelligence applications that can be integrated into the sub-components of the main dimensions of logistics processes. Based on future research findings and insights, more comprehensive conceptual frameworks can be developed for subcomponents of logistics processes at this early stage of AI applications in logistics.

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