Logistics 4.0: A Primer

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ABSTRACT

Logistics 4.0 refers to the application of information and communication technologies to all aspects of the supply chain, integrating tools such as artificial intelligence, the Internet of things (IoT), blockchain, robotics, and much more. The concept is closely linked to Industry 4.0, also known as the Fourth Industrial Revolution. The primary goal of Logistics 4.0 is to coordinate and modernize supply flow. Logistics 4.0 ensures companies' entire distribution process is carried out cohesively and intelligently. Today, the logistics industry is undergoing a major transformation with the advent of Logistics 4.0, turning manual and traditional logistics processes into modern and innovative operations. Internationally, smart logistics solutions are already accepted and frequently used. Companies missing this trend, will sooner or later be outdone by their competitors. In this paper, we explore how logistics and Industry 4.0 transform traditional approaches in the supply chain.

KEYWORDS: *logistics, supply chain, transportation, Logistics 4.0, Industry 4.0.*

INTRODUCTION

The 21st century has seen rapid changes in technology in the form of automation and increased connectivity. The term Industry 4.0 denotes the transition to digital manufacturing or the fourth industrial revolution. Industry 4.0 captures the computerization and automation of manufacturing processes via smart technologies such as artificial intelligence, machine learning, big data, and advanced analytics. The potential of Industry 4.0 may be realized in many sectors, including logistics and supply chain. Logistics 4.0 (or L4.0) is the adoption of industry 4.0's principles, procedures, and technologies to create smart supply chains [1]. Figure 1 shows a typical logistics [2].

Logistics has become a core pillar in the value chain for suppliers, manufacturers and retailers. Logistics 4.0 is revolutionizing the way we manage supply chains. The rise of Logistics 4.0 marks the beginning of a new era in supply chain management, driven by advanced technologies such as artificial intelligence (AI), Internet of things (IoT), big data, robotics, simulation, and innovative logistics software. Artificial intelligence (AI) has greatly improved logistics and had a major impact. AI will play an important role in improving the efficiency, productivity, and competitiveness of the logistics. The Internet of things plays a central role in Logistics 4.0. The use of IoT devices enables companies to monitor their goods in real time. The developments in big data could deliver numerous benefits to the food logistics sector. Robotics refers to the process of designing and using a robot to carry out specific tasks, while automation is the use of other forms of automatic mechanized technology. Simulation is a key building block of Industry 4.0 technologies and often used for planning and developing exploratory models for efficient decision-making as well as to design operations of complex production systems.

WHAT IS LOGISTICS 4.0?

The business landscape is increasingly shifting toward digitalization, focusing on overcoming challenges and complexities while improving accessibility. The digital transformation in logistics is more than just a trend; it is an indispensable response to the complex demands of the global markets. Modern industry has been developing for several centuries and so far there have been four industrial revolutions, marked by innovations, changes, new production methods, and influences on all other fields. Logistics went through phases, from Logistics

1.0 to the present day Logistics 4.0. The concept of Logistics 4.0 has its roots in Industry 4.0 (or I4.0), which was introduced by a German initiative to use digitalization to improve the competitiveness of traditional manufacturing industries. Industry 4.0 originated in 2011 at the Hannover trade fair. It was initially based on the following nine pillars: Robotics and automation, Big data, Simulation, System integration, Internet of Things, Cybersecurity, the Cloud, Additive manufacturing (3D printing) and Augmented reality. The main objective of Industry 4.0 technologies is to make manufacturing more cost-effective, to provide agility and flexibility with high-speed manufacturing and enhanced quality. The key idea of Industry 4.0 was to implement high-level smart automation, robots, cyber-physical systems, and information technology in general to produce next-generation competitiveness in manufacturing and operations. Industry 4.0 is is the initial reason for the introduction of Logistics 4.0 [3,4].

Logistics 4.0 is the digital transformation of supply chains, applying Industry 4.0 technologies like AI, IoT, big data, and automation to create smart, interconnected, and highly efficient logistics systems. It represents a significant advancement in the field of supply chain management, and artificial intelligence (AI) plays a key role in this transformation. The application of AI in logistics is not just a trend but a crucial factor in enhancing competitiveness and swiftly responding to market changes. AI helps forecast and optimize transportation routes, minimize waste, and enhance efficiency. One of AI's primary benefits is its power to predict and improve shipping routes. Artificial intelligence can anticipate and analyze traffic patterns and weather to identify the most efficient shipping routes [5]. Figure 2 is a representation of Logistics 4.0 [5].

Logistics 4.0 creates a "smart supply chain" where physical assets (trucks, warehouses, products) are connected to digital systems, sharing data continuously. This data feeds analytics, allowing for automated actions, such as rerouting a delivery, adjusting warehouse stock, triggering maintenance, or creating a self-optimizing system. Logistics 4.0 works with different technologies that are common to smart corporate settings. One solution that can help manage Logistics 4.0 in a company is integrated management software, which centralizes all the tools and data the company needs in a single place [6].

APPLICATIONS OF LOGISTICS 4.0
The logistics sector adopts digital technologies to tackle business challenges and enhance performance. Logistics 4.0 involves the coordination of material and information streams within enterprises, overseeing transportation, storage, and associated data to deliver products efficiently and cost-effectively. Key logistics components include procurement, manufacturing, distribution, and reverse logistics. Common applications of Logistics 4.0 include the following [3,4]:

➤ *Food Logistics 4.0:* This is a term derived from Industry 4.0 focusing on all the aspects of food logistics management based on cyber-physical systems. It states that real-time information and the interconnectivity of things, supplemented with novel technologies will revolutionize and improve the way food logistics is carried out. Food logistics is a vital element of the food supply chain. It is an important aspect of fulfilling consumer demands by providing the right product and quantity at low-cost and on-time delivery with minimum or no food waste. It has tremendous potential in terms of bringing transparency, swift delivery of food at reduced cost, flexibility, and capability to deliver the right quality product at the right place and at the right time.

➤ *Tracking and Tracing:* Tracking and tracing are an example of generic logistics applications empowered by information technology. The technical implementations of tracking and tracing systems are often simple but can enable advanced logistics decision-making. Tracking refers to the application of following a shipment in real time for decision-making purposes. Tracking systems answer the question of where the package is at a particular moment or where it has been seen last. Tracing looks at the same kind of event log of a shipment retrospectively. The question is from where and when this package has come. These kinds of questions of origin are important for many applications. Traceability and trackability are the keys to product safety, especially in food-related operations.

➤ *Smart Utilities:* The traditional logistics components have been quickly replaced by "smarter" versions in recent times, which has largely transformed how shipments are circulated all the way from suppliers to their end-users, often supported by platforms like a supplier management portal that streamline communication and coordination. Instilling technological solutions like smart containers and smart pallets into logistics utilities has transformed traditional shipping workflows.

➤ *Predictive Analytics:* Given the amount of data produced in logistics, predictive analytics will play a central role in the future. With this method,

history data are used to make predictions for decision-makers. With the help of appropriate tools, history data, for example from warehouse occupancy, can be evaluated to improve the use of space and reduce the picking efforts. This also helps to reliably predict the quantity assignment and personnel request. The prerequisite for such an analysis is bundling relevant information.

BENEFITS

The implementation of Logistics 4.0 technologies enables companies to make their supply chains more efficient, flexible, and resilient. With Logistics 4.0, businesses can achieve higher flexibility, reduce costs, and promote sustainable development. Logistics 4.0 facilitates the shift towards more customer-focused supply chains. In Logistics 4.0, everyday objects like pallets and products become "smart" through the use of sensors and RFID technology. Other benefits include the following [7]:

➢ *Automation:* Automating operations mainly increases productivity by decreasing the time required to carry out tasks, thus increasing output and profit. Logistics 4.0 leads to automation of warehouse and transport processes. In warehouses, the use of collaborative robots (cobots) and automated carts (AGVs) has helped automate the order selection process. AGVs carry and load goods automatically in warehouses, leaving the factory without a human driver to verify inventory or track the location of goods. Amazon's automation system is an excellent example of applying artificial intelligence in warehouse management.

➢ *Transparency:* The availability of real-time information is a core feature of Logistics 4.0. It enables companies to quickly respond to changes and develop proactive strategies to address challenges and bottlenecks.

➢ *Visibility:* The logistics sector, driven by advanced technology, can lead to an increase in visibility and transparency from digitization across the entire supply chain management. Visibility will encourage businesses to build a smart system. It will also prove to be a crucial prerequisite, which will make logistics intra-operational, transparent, and efficient.

➢ *Reduced Waste*: The intelligent use of data helps minimize waste in logistics. Predictive analytics reduces overstocking and understocking, while real-time tracking prevents lost shipments. Technology also enables businesses to optimize their use of resources, contributing to sustainability in the industry.

CHALLENGES

Adopting Logistics 4.0 is not without challenges. Implementation requires substantial investments in technology and personnel training. The disadvantages of Logistics 4.0 are primarily the consequence of high demands relating to organizational, technical and software solutions. For traditional logistic companies, the most difficult hurdle to overcome would be getting rid of the spreadsheet to carry out business operations. One of the major challenges of Logistics 4.0 is the need for organizations to adapt to new technologies and processes. Another challenge is the need for organizations to adopt a data-driven approach to logistics. Other challenges include the following [4]:

➢ *Ethical Concerns:* Given the importance of ethics and morals in organizations and the crucial factors underlying their development, it has been noted that leadership is among the most significant contributors to this objective. This approach aims to ensure that organizations managed by these leaders become more humane, respectful, responsible, and ethical, ultimately serving as true examples of altruism—prioritizing the well-being of others.

➢ *Integration:* This is the process of connecting various subsystems into one cooperating system to deliver overarching functionality. What stands out for Logistics 4.0 is that it is capable of collaborating and integrating with Industry 4.0 procedures and systems. Interoperability, data integration, robustness, stability, and scalability need to be considered for the full benefits of a distributed, modular system to be realized. The opportunities presented by system integration include decreased costs and improved efficiency, competitive advantage, and offering better products to customers. Challenges to system integration include an unwillingness to share data or outsource certain operations to third parties, unclear communication and responsibilities, functionality disagreements, cost of integration, insufficiently skilled human resources, and lack of standards for integration.

➢ *Cybersecurity:* The information related to data involved in logistics planning and execution is plentiful. Targeted attacks have been steadily increasing worldwide spanning all industries and sectors, including businesses, schools, hospitals, governmental websites, etc. Whenever a new technology is introduced into an industry, cybersecurity becomes an issue. To prepare for technology's adverse consequences, companies must ensure their systems are secure.

FUTURE OF LOGISTICS 4.0

The requirements to logisticians in all domains and all over the world increase daily. If companies fail to provide their products at the right time, in the right quantity, and at the right price, they can no longer satisfy their customers' complex requirements. Throughout history, the field of logistics has developed and continuously adapted to the needs of the population, current technological trends, and industry. Intelligent solutions are the basis for the logistics of the future. Future-proof solutions are systems that can be used flexibly and on a mobile basis [8].

Logistics 4.0 is not just a passing trend but the future of logistics and transport. It represents a necessary evolution to meet the demands of a globalized and rapidly changing world. The road ahead is one of more autonomy across various logistics components such as supply chain logistics, inbound logistics, warehouse management, intralogistics or line feeding, outbound logistics and logistics routing. In the future, the growth of AI promises to continue to alter the logistics sector, offering up new possibilities and allowing firms to not only adapt but even lead in a competitive market. One of the best images depicting the evolutions towards more autonomy across all these areas is the roadmap image in Figure 3 [9]. Several countries, including the United States, China, and Japan, have adopted strategies to bolster their manufacturing sectors through technological advancements

CONCLUSION

Logistics 4.0 is related to the fourth Industrial Revolution, where information and communication technologies (ICT) have assimilated to form the solid foundation for innovative industrial technologies that lay ahead in the future. The term entails the digitization of the industrial sector, resulting in the digitization of the physical elements and how they work. Logistics 4.0 allows you to increase your business's efficiency while granting a number of benefits. The adoption of Logistics 4.0 technologies increases efficiency, reliability, and customer focus within the logistics industry. Logistics 4.0 seems like a lucrative value-added proposition for all the businesses that wish to drift away from the complexities of a global supply chain [10]. It is radically transforming the landscape of transport and logistics, ushering in a new era of efficiency, transparency, and innovation.

The introduction of Logistics 4.0 is becoming an imperative for all companies that want to stay on the market. This requires large investments, changes in the methods of work and decision-making, contemporary education, and employee training. To develop a better-connected and smarter supply chain process, companies need to implement Industry 4.0. Logistics 4.0 represents a transformative era for the logistics industry, offering a wealth of opportunities as well as challenges To take advantage of these opportunities, organizations need to be prepared to invest in new technologies and processes and adopt a data-driven approach to logistics [11]. More information on Logistics 4.0 is available from the books in [12-18] and in a related journal: *Logistics.*

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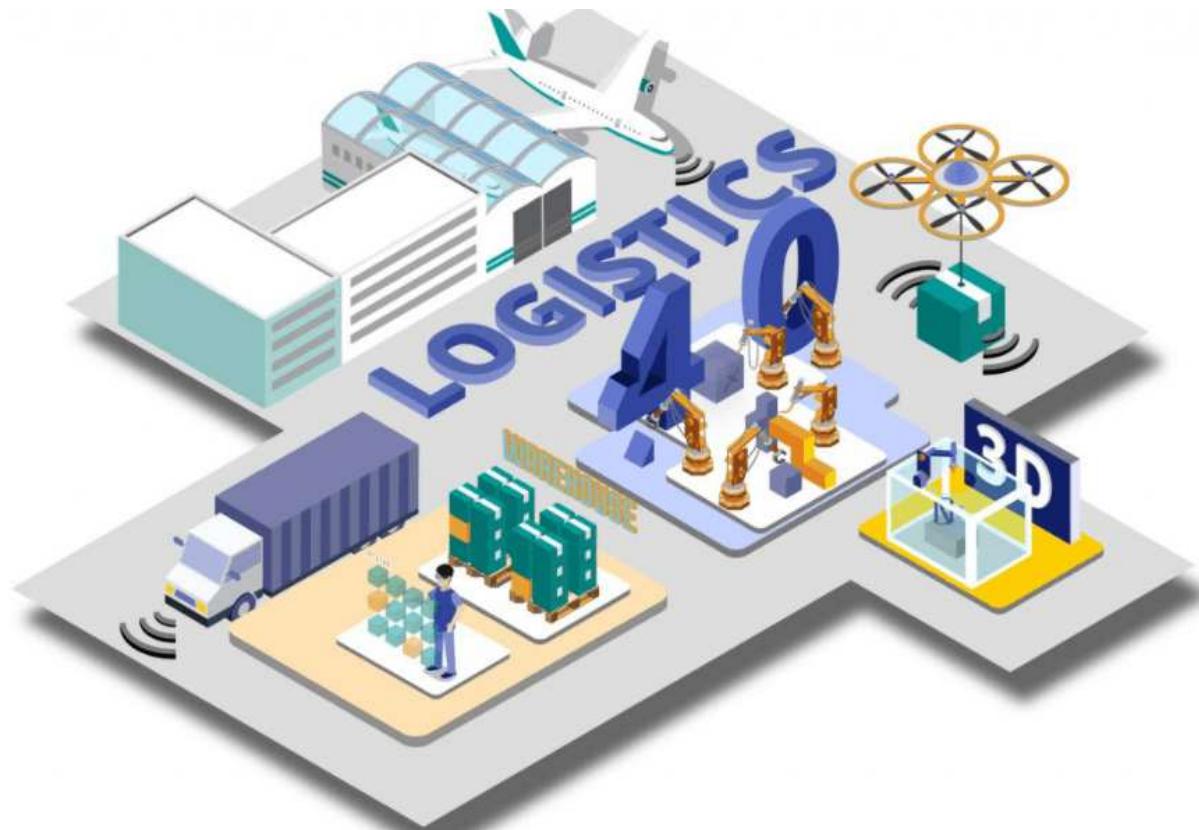
Figure 1 A typical logistics [2].

Figure 2 A representation of Logistics 4.0 [5].

Figure 3 Evolutions towards more autonomy [9].