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Supply Chain Management And Logistics In The Industry 4.0 Environment: A Theoretical Evaluation

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Abstract

Digitalization, openness, real-time data availability, and collaboration are some of the technology trends that are considered to define Industry 4.0, the fourth industrial revolution. The Internet of Things (IoT) and enhanced cyber-physical systems unite the digital and physical realms in this new industrial paradigm. The global economy and markets are poised to be impacted by this industry transformation, which is predicted to enhance manufacturing processes and boost productivity. The study aims to provide an overview of the components of Industry 4.0, which was conceived in 2011, and to describe these concepts in detail with their historical development, emphasizing the characteristics, fundamental characteristics and implications of the concepts of the digital supply chain and logistics 4.0 that emerged as a result of the impact of industry 4.0. The phrase "Industry 4.0" encompasses a wide range of innovative technologies, including but not limited to: cyber-physical systems, robots, the internet of things, cloud computing, augmented reality, artificial intelligence, data security, big data, and the internet of services. Following three previous industrial revolutions that brought about enormous efficiency gains and societal and economic shifts, the idea of Industry 4.0 represents the world's fourth industrial revolution. Under Industry 4.0, everything in the production chain, including suppliers, carriers and products, is digitally connected.

Keywords: Industry 4.0, Logistics 4.0, Smart Logistics, Digital Supply Chain

1.Introduction

Many technologies come together to form what is known as Industry 4.0. These include big data, cloud computing, augmented reality, artificial intelligence, data security, cyber-physical systems, robotics, the Internet of things, the Internet of services, cyber-physical systems, and the Internet in general. When it comes to production, the next big thing is Industry 4.0. The first three industrial revolutions made significant leaps in efficiency and affected people's lives and the industry. Within the scope of Industry 4.0, everything in the production chain, including suppliers, carriers and products, is digitally connected (Khin and Kee, 2022).

The idea of Industry 4.0 has a considerable effect on various changes in business models, output, and production methods. Increased productivity, flexibility, faster production, and higher-quality products are all benefits of mass customisation. Because of additive manufacturing and equipment that can be quickly configured to meet customer needs, mass customisation will allow even tiny batches to be produced. Because prototypes and new products may be made quickly without the need for complicated new tooling and moulds or the installation of new production lines, this flexibility also fosters creativity. Consequently, a single product with multiple variants may be mass-produced with minimal inventory using Industry 4.0 technologies (Rüssmann et al. 2015:9). In addition to this, understanding the relationship between Industry 4.0 and

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sustainable development is important. This relationship will also bring about measures that can be taken against climate change in the logistics sector (Ulusoy,2023).

Increased digitalisation, the integration of product valu e chains, and novel approaches to doing business—or complete integration—are the hallmarks of Industry 4.0. A new degree of value chain control and organisation over a product's whole life cycle is represented by this idea. The product idea, client demand, design, manufacture, ordering, delivery, and recycling are the first steps in the cycle. All supply chain operations, as well as extra actions related to adding value to the product, are included in the value chain. The foundation of Industry 4.0 is the real-time availability of all data about the interconnectivity of every link in the value chain (Radivojević and Milosavljević, 2019:285).

Industry 4.0 has caused change and shifts in logistics and supply chain, as in every field. Barber's logistics and supply chain can achieve a more competitive, efficient, and adaptable structure by using the advantages of Industry 4.0. Therefore, digitalization provides a significant strategic advantage in this sector. In this context, this study mentions the concept of Industry 4.0 and the digitalization process in supply chain and logistics with this revolution.

2. Industry 4.0 Concept

2.1. History of Industry 4.0

The concept of Industry 4.0 has gained immense popularity and importance since its 2011 introduction by the German government at the Hannover Fair. The fundamental goal of each industrial revolution has been to increase efficiency. One factor that accelerated the first industrial revolution was the development of steam power, which increased output. The Second Industrial Revolution began with the introduction of electricity as a means to increase productivity. The third industrial revolution was brought about by the use of electronics and information technology to increase output and efficiency (Rojko, 2017).

It was in the middle of the eighteenth century in England when the steam engine was invented, and the first industrial revolution came with it. In the late 19th and early 20th centuries, the United States and Europe started the second industrial revolution. Mass production and the substitution of chemical and electrical energy for steam were the hallmarks of this revolution. Conveyor belts were first used in Cincinnati, Ohio, slaughterhouses during the Second Industrial Revolution. Manufacturing of Ford T models in the US reached its zenith in the years that followed. Because mass manufacturing is an advantage, the advent of conveyor belts and continuous production lines has resulted in extremely high productivity increases. The critical technological development that started the third industrial revolution was the launch of the integrated circuit. One of the main characteristics of this revolution, which began to take shape in many industrialized nations in the latter half of the 20th century, is information technology and electronics use to increase manufacturing automation (Demir et al., 2020).

2.2. Characteristic Features of Industry 4.0

In order to meet trends in autonomy, digitization, transparency, modularization, mobility, and socialization of processes and products, a value chain's radical innovations are combined to form Industry 4.0. Digitization is the most significant attribute, which also makes other characteristics possible. Entire factories and production facilities can function with minimal human-machine contact thanks to autonomous decision-making and learning. Global supply chains are known for their highly intricate structures, but new "Industry 4.0" technologies make the entire value creation process more transparent. Device mobility is altering how consumers and businesses connect and how machines communicate and cooperate throughout production. The modularization of products and the installation of production facilities that allow the whole value creation

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process are both made possible by Industry 4.0 technology. Modular production facilities can adjust production quantities autonomously, increasing production process flexibility. While members of our society engage in social networks, the operations of businesses are defined and actions are decided upon through the interaction of humans and machines within specific networks, both within and outside of the company's organizational boundaries (Pfohl et al. 2015:37-40).

2.3. Distinctive Elements of Industry 4.0

The term "industry 4.0" refers to a broad range of modern automation systems, data interchanges, and industrial technologies. There are three types of distinguishing features of Industry 4.0. These are speed, breadth and depth, and system impact**.** **Speed:** Unlike previous industrial revolutions, Industry 4.0 is developing at an ever-increasing rate more than a linear pace. Our complex, intricately linked world and the fact that new technology breeds newer, more powerful technologies are the causes of this. **Breadth and depth:** Building upon the digital revolution, it integrates several technologies, causing previously unheard-of paradigm transformations in business, society, the economy, and the individual. This is changing not only “what” and “how” we do things, but also “who we are.” **System Impact:** Entails the complete overhaul of organizations, sectors, industries, nations, and society at large. (Schwab, 2017:8-9).

2.4. Components of Industry 4.0

2.4.1. Cloud Computing

Cloud computing, or simply “The Cloud,” is a type of outsourcing that brings together multiple computing servers and resources in real-time on a pay-per-cycle or on-demand basis to deliver computer programs, over-the-top services, and resources on a single platform. It plays a leading role in improving today's industry and transforming it more efficiently. There are three tiers of service delivery in cloud computing. Software as a service, platform as a service, and infrastructure as a service all offer different levels of virtualization and solution stack management (Bhardwaj et al., 2010:60-61).

Like smart manufacturing, cloud manufacturing is an innovation of the present manufacturing paradigm that applies cloud computing technologies to the manufacturing sector. A customer-focused manufacturing model known as "cloud manufacturing" lowers costs associated with the product lifecycle, boosts productivity, and allows for efficient resource loading in response to tasks generated by customers and fluctuating demand (Terrissa et al. 2016:611).

Logistics businesses can benefit significantly from cloud computing since it offers quick, easy, and flexible access to cutting-edge supply chain solutions and information technology services. Logistics firms will no longer need to establish their own IT departments, invest in software and hardware infrastructure supply, or plan integration with business partners thanks to cloud computing technologies.

2.4.2. Internet of Things (IoT)

The term "Object" needs to be defined before the idea of the Internet of Things (IoT) can be determined. An "object" can be anything that exists in the physical world or in the digital realm and can be seen as such. Typically, things are given names, numbers, and addresses to help them be located. An essential aspect of the future Internet is the Internet of Things (IoT), a dynamic worldwide network of physical and virtual "objects" that can communicate with one another using standard and interoperable protocols; these "objects" will have identities, physical traits, and virtual personalities; they will be able to self-configure; they will use intelligent interfaces; and they will be seamlessly integrated into an information network. Network infrastructure is one way to describe it (Sundmaeker et al., 2010:43).

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Industry 4.0 is propelled by the Internet of Things (IoT), enabling advanced automation, data collection and analytics, and process and workflow optimisation. Also, manufacturers will have an easier time making sense of real-time supply chain data due to the Internet of Things (Shrouf et al., 2014:700). Among the various logistical objects to which identification technologies are applied are smart containers, pallets, packing, cars, racks, forklifts, infrastructure, ports, and terminals. Different internet-based connectivity models are available for logistics systems, the first internet-of-things solutions that provide worldwide connectivity for all participants and items (Radivojević et al., 2017:185-186).

2.4.3. Big Data and Data Mining

In manufacturing, machines may be equipped with one or more microprocessors to gather production data. This vast network of sensors and microprocessors creates a massive data source larger than conventional scales. This enormous amount of data collecting is difficult for traditional database systems to capture, store, manage, and analyse. Manufacturing businesses have to handle many data from a management standpoint, including a lot of structured and unstructured data on their products, operations, value chains, and external sources. Manufacturing businesses will need to handle more kinds of pertinent data while simultaneously accepting many customers' individualised data from the Web in real-time as mass customisation and network collaboration advance. Big data technology swiftly extracts valuable information from many data kinds to enable deep comprehension, insight, wise decision-making, and discovery. To store, evaluate, and make decisions that will direct the production process, massive amounts of data will be transferred to a cloud computing data center during this process. Manufacturing businesses will gain a lot from big data and extensive data analysis, including process optimisation, cost savings, and increased operational effectiveness (Zhou et al. 2015:2150).

Logistics 4.0 describes a dramatic increase in the variety, velocity, and quantity of data processing. Businesses can generate new revenue streams and establish innovative company strategies by utilising big data analytics techniques and data mining. Data mining makes it possible to uncover links, logic, hidden knowledge, and laws in data. Data mining can forecast consumer behaviour and market trends and identify the root causes of bugs and problems.

2.4.4. Cyber-Physical Systems

The seamless integration of computational algorithms with physical components is the foundation of Cyber-Physical Systems (CPS). Developments in CPS will provide capabilities, adaptability, scalability, flexibility, security, and usability beyond what is now available in basic embedded systems. Innovations in industries including manufacturing, energy, transportation, agriculture, automation, and healthcare will be facilitated by cyber-physical systems. CPS combines processing, communication, and storage capabilities to seamlessly integrate virtual and physical spaces in real-time while maintaining security and dependability. By merging the real and virtual worlds and doing away with their borders, CPS is also seen as a significant Industry 4.0 technology. Production systems for Industry 4.0 will be cooperative and comprise a range of communication agents, such as software, human, and physical agents (Xu et al., 2018:2947-2948).

An architectural framework known as Cyber-Physical Production Systems (CPPS) was developed by integrating cyber-physical systems with industrial production systems. This system bridges the gap between the virtual and physical realms, paving the way for smarter machinery in smart factories and, ultimately, innovative production. Conventional manufacturing mechatronics systems will be replaced by CPPSs, allowing for tailored data collection and transmission of the collected data to massive data centers for cloud computing access. CPPS facilitates IoT in manufacturing. As a result, the CPPS idea will boost independence

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and adaptability in the workplace, enabling a greater degree of system and application integration and interoperability for production (Perez et al., 2015:1).

2.4.5. Smart Factories and Smart Robots

Smart factories, expressed as the factories of the future and thought to be a new definition, is one of the essential results of Industry 4.0. These factories are highly systematic facilities based on production with intelligent systems and where processes are interconnected. In today's complex environment, a smart factory is a manufacturing system that offers flexible production methods to deal with issues in a production facility with dynamic and changing boundary conditions. This specific solution can be associated with automation, which is defined, on the one hand, as a set of hardware, software, and mechanics that optimise manufacturing in order to reduce wasteful labour and excessive use of resources. On the other hand, intelligence can emerge from forming a dynamic organisation when different industrial and non-industrial partners work together (Hozdic, 2015:31).

Robots play an essential role in modern manufacturing. Intelligent robots that can carry out jobs emphasising safety, adaptability, versatility, and cooperation are an integral part of Industry 4.0's autonomous production procedures. It enables many possible application opportunities in industries, making integration into personnel work areas more economical and productive without isolating the work area. Robots in Industry 4.0 will be more cooperative, adaptable, autonomous, and able to communicate with one another. Along with learning from people, they can operate securely beside them. These robots would be more affordable and capable than those currently used in manufacturing (Bahrin et al. 2016:139).

2.4.6. 3D Printers

3D printing or additive manufacturing is the term used to describe various techniques used to create three-dimensional solid items from digital files. With this technique, a computer design may be translated into a tangible product with micrometer accuracy in a matter of hours. Different placements are made for successive layers of material. When compared to traditional machining procedures, which include cutting or drilling to remove material, 3D printing involves adding layers one after the other. As a result, it builds an object layer by layer until the full thing is created using a layering process. 3D printing can help us transition from huge manufacturing lines to customised, one-off items (Mpofu et al. 2014:2148).

The lack of industrial waste is one of the critical benefits of this method. 3D printing can be considered a "green" technique since the printing material is added layer by layer under computer control in the amount needed for the production specification. Because of this technology, producers only need three items to print the same objects anywhere in the world: printing material. This digital file can be supplied rapidly to any location in the world, and a printer. Regardless of an object's shape or present industry constraints, additive manufacturing can make it. This ability allows manufacturers to go from making complex products to simpler ones without increasing production costs or depleting raw materials (Dumitrescu and Tanase, 2016:35).

2.4.7. Horizontal and Vertical Integration

Many of the IT solutions in use today need more complete integration. Seldom are businesses, suppliers, and customers tightly related—similarly, divisions like engineering, manufacturing, and customer support. Business processes and shop floor operations need to be fully connected. Everything is separate in engineering, not even between products, manufacturing, and automation. Automation of value chains, which will significantly improve the alignment of businesses, departments, functions, and capabilities, is a potential outcome of Industry 4.0's ubiquitous, cross-company data integration networks (Rüssmann et al. 2015:3).

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Cyber-physical systems are mechanically complicated systems that combine digital hardware and software components, information technology systems, and mechanical or electronic components capable of independent communication. For horizontal and vertical integration, the interactions between these complexes open up a whole new realm of system functioning. It is essential to integrate network information technologies and production systems along the value chain to ensure the free flow of data and information between companies in different locations. Horizontal integration refers to merging various manufacturing information technology systems and automated machines at multiple stages of the planning and production process (Chukalov, 2017:155).

IT and production systems are instantly accessible thanks to the Internet of Services and Things. The data is processed and returned as sufficient information for management due to vertical integration of data and information from the workplace to corporate and production level control and operation. The term "vertical integration" describes connecting several levels of automation and industrial equipment with information technology systems. The production cyber system is based on real-time vertical and horizontal collaboration across the machine-to-person, machine-to-internet, and machine-to-machine value chains (Chukalov, 2017:155).

3. Industry 4.0 And Supply Chain Management

The very foundation of supply chain management has been turned upside down by Industry 4.0. Supply chain 4.0, also known as digital supply chain, smart supply chain, or just supply chain, is a new paradigm in supply chain management that arose due to Industry 4.0 technology. The supply chain is becoming increasingly complicated and globally distributed, necessitating a heavy reliance on technological advancements, robotics, and AI. Since globalisation has made it imperative to ensure proper integration of activities from suppliers to customers, this is the current goal of the supply chain. Within the scope of Industry 4.0 components, supply chain integration involves making joint decisions about costs, inventory, and customer services from a whole process perspective, as well as collaboration, information sharing, and system standardisation, rather than managing each function separately. Integration involves implementing cutting-edge technological tools to improve information exchange and facilitate tracking of physical goods throughout the process (Perussi et al., 2019:34).

In the quest for a competitive edge, digitalization and Industry 4.0 technologies have grown in importance within supply chain management. Industry 4.0 facilitates collaboration and rapid exchange of information across various supply chain values. Supply chain participants can now transform repetitive tasks into a simpler structure. They can provide cost reductions in a variety of functional areas, including ordering, customer service, development planning, IoT, warehousing, inventory control, and supplier operations. Companies can use Industry 4.0 technologies to explore innovative collaboration opportunities and refine their supply chain strategies (Frazzon et al., 2019:184).

Being ready for these revolutionary advances made possible by Industry 4.0 is essential as it enables the supply chain to be more efficient. Companies use flexible networks of suppliers to offer a range of products. It also provides a significant competitive advantage in dealing with the complexity and uncertainty associated with customers' changing behaviour.

3.1. Characteristic Features of Supply Chain 4.0

There are nine distinguishing features of an intelligent supply chain. These: **Equipped:** Various devices and real-time data are part of the smart supply chain. **Interconnected:** The digital supply chain collects real-time information and shares it with the entire network. **Smart:** Supply chain 4.0 can react and decide, optimising its own processes. **Automated:** There will be little human involvement in the smart supply chain

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because most of its transactions and operations will be automated. **Integrate:** Using its intelligence, the intelligent supply chain will work together to integrate and self-optimize, striving for a global optimum that considers all linked enterprises. **Innovative:** Over time, the supply chain will be able to adapt and reach new values by innovating and evolving. **Transparent:** GPS and CPS technologies will provide greater visibility into the product's traceability (e.g., origin evidence and material location) and supply chain (e.g., delays). **Proactive:** A combination of real-time data analytics, machine learning, and artificial intelligence will allow decision-makers to respond intelligently to changing conditions and unforeseen events. **Customer-focused:** Making it possible to design, produce and sell personalised products with increased flexibility and innovative technologies such as additive manufacturing (Wu et al., 2016:5-6).

3.2. Supply Chain Performance

One of the critical subjects in supply chain management literature is supply chain performance. Supply chain performance was assessed by Najmi and Makui (2012) through an examination of asset management, flexibility, responsiveness, quality, and reliability. Performance criteria related to efficiency, effectiveness, timeliness, and quality were also taken into account by Bourlakis et al. (2014). Performance improvements were also determined by Dreyer et al. (2016) in terms of availability, pricing, time, innovation, and diversity.

According to Baihaqi and Sohal (2013), information sharing is crucial for maintaining supply chain relationships and improving performance. To ensure effective information sharing—and, by extension, better supply chain performance—businesses are investing in technological advancements that enable efficient communication channels and methods for collaboration (Mangla et al., 2017:18).

Supply chain agility and adaptability also significantly influence supply chain performance. Additionally, it is well known that enhanced supply chain visibility and transparency greatly improve operational performance (Swift et al. 2019:3).

Cooperation and integration throughout the supply chain provide flexibility, which is another factor that improves supply chain performance. When systems are integrated, information can be shared more effectively, increasing collaboration. This can potentially enhance operational performance by making it more responsive and flexible (Fawcett et al. 2008:37).

In their study, Dudukalov et al. (2021) demonstrated how adopting and investing in emerging technologies can give businesses a lasting competitive edge through increased information availability, cost savings, better product quality, responsiveness, and teamwork abilities. Implementing Industry 4.0 technologies and digitalisation in supply chain management will yield significant enhancements. Integrated management can greatly aid Digital supply chain integration, which also helps lessen the industry's fragmented structure. It offers a sustainable perspective on digital technologies as well. By developing Industry 4.0 technologies and increasing consumer data access, businesses strive to improve their services, availability, and utility. Building lasting relationships with each client is their top priority thus they seek to improve supply chain efficiency.

3.3. Challenges Related to Supply Chain Management and the Impact of Industry 4.0

The supply chain must manage supplier-partner relationships, people, costs, and customer service. Supply chain managers need help to create and maintain efficient and effective systems. Customer service: Contrary to appearances, supply chain management focuses on delivering the correct product at the right time in quantity. This process may take time. Manage costs: Many factors strain operational expenses. These include technology, more foreign clients, new laws, more human costs, and rising commodity prices. Strategy, risk mitigation: Reviewing and revamping often in response to market developments is essential for maximum efficacy and efficiency. Market transitions include new product launches, overseas sourcing, financial

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availability, and IP protection. Recognising and measuring market risks helps regulate and prevent them. Management of supplier-partner relationships: Set, maintain, and monitor mutually agreed-upon standards to understand performance and innovation better. Time is needed to measure performance and communicate well. Talent: Finding qualified candidates is becoming more challenging. A supply chain manager's capacity to train new leaders and understand supply chain basics are crucial (Muthusami and Srinivsan, 2018:33).

Industry 4.0 principles in supply chain management can cut costs and boost productivity, efficiency, flexibility, and product customisation. Industry 4.0 uses cutting-edge tools and technology to reimagine industrial processes. Supply chains are rapidly automating, digitising, and becoming agile. Current digital supply chain networks use several technologies to provide efficient, open, flexible, and transparent systems from product invention to production, sourcing, planning, logistics, and marketing. Industry 4.0 affects supply chain management and staging. These include smart storage and truck routing systems, integrated flow, improved supplier performance, real-time information sharing and synchronisation, and more accurate forecasting and planning due to material and product traceability. Shared information and coordinated operations can make supply chains more efficient and nimbler. This reduces expenses and boosts performance (Ghadge et al. 2020:6).

4. Industry 4.0 And Logistics 4.0

Logistics systems, in addition to all industrial processes and functions, will also be drastically altered by the Industry 4.0 revolution. A revolution in logistics known as Logistics 4.0 has occurred due to Industry 4.0. Accessibility, quick information processing, security, visibility, novel networking opportunities, supply chain automation, and—above all—the chance to extract more excellent value from the process are all provided by Logistics 4.0. Because of all these factors, Logistics 4.0 will be very important. Industry 4.0 includes logistics 4.0, which provides a framework to assist the growth of Industry 4.0. Supplying the correct goods—in the correct amount, in the proper manner, at the right time, from the right source, in the right way, and at the right price—will be affected and changed by Industry 4.0 (Demir et al., 2020b).

4.1. History and Development Process of Logistics 4.0

Logistics has undergone four significant changes. The automation of transportation by water- and steam-powered equipment in the late 19th and early 20th centuries led to Logistics 1.0. Ships and trains with steam engines carried large amounts of freight and containers over long distances, not humans or animals. Transport capacity has increased substantially as railway and sea transit have replaced the heavily used roadway. Since the 1960s, mass industry and electricity have mechanised transportation, resulting in logistics 2.0. Automatic loading and unloading systems, warehouses, and sorting systems have made logistics easier. Electric motors power these equipment. Electronic warehouse equipment replaced manual equipment as the port used container ships more. Information technology and computers in the 1980s led to Logistics 3.0, the systematisation of logistics management. With the emergence of information technology solutions like Transportation Management Systems and Warehouse Management Systems, logistics management, inventory, and shipment automation and efficiency have dramatically risen. The fourth revolution is advancing in logistics and the internet of things (Wang, 2016:69).

Sustainable Logistics 4.0 requires resource planning, transportation management, intelligent transportation, information security, and warehouse management systems. If supply chains change, Industry 4.0 resource planning management methods that leverage cyber-physical systems will boost productivity, flexibility, and agility. Visibility, transparency, alignment, and integration among major supply chain actors will ensure adequate resource forecasts (people, materials, and equipment), optimising resources and processes. Management systems for warehouses: Warehouses have long been the hub of commodity movement in supply chains. They must be a major competitive advantage for logistics companies in the contemporary economy.

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Industry 4.0 will transform warehouse operations. Transportation management systems focus on logistics in supply chain management. It connects an order management system to a warehouse or distribution centre. Uses virtual operations, sensor technologies, telecommunications, computing hardware, positioning systems, data processing, and planning methods. Integrating virtual technology is a revolutionary notion altering transportation and solving global community challenges. Companies seek low-cost technology innovations to improve services and gain a competitive edge. This concerns data security. Information security is essential for a productive business as it relies more on technology. Emerging technologies often contain security weaknesses that reveal hidden risks. In this climate, organisations must protect their IT systems and data (Barreto et al. 2017:1248-1250).

4.2. Components and Technologies of Logistics 4.0

Data collection, quality control, planning, optimisation, and automatic identification of logistical objects and participants are available in real-time. Intelligent management, innovative commercial offerings, and fresh information are conceivable with data processing and analysis. The leading technologies used to execute the above components are real-time location, automatic identification, automatic data collection, data processing and analysis, networking, and business service integration. Automatic Identification: Computer, optical, mechanical, electrical, communications and other technologies are needed to produce a highly automated data collection technology. A real-time location system may identify and monitor objects or people in a building or confined space. Real-time location systems are essential for assembly line vehicle monitoring, warehouse pallet locating, and hospital equipment tracking.

Automatic data collection: Smart sensors automatically detect the "right product" and record the "right time", "right quantity", "right quality", "right price", "right location", and "right status". It's possible. Real-time big data involves more than just storing enormous datasets in databases. Data mining analyses massive data from numerous sources to find patterns, rules, trends, and information. The decision-making process is facilitated. A commercial service is when one party temporarily uses another's resources to perform a function and obtains a benefit. Relationship and Cohesion: The Internet of Things connects devices to a network to gather and share data. It can monitor and control each item's logistical process and resource and information transfer (Wang, 2016:70-71).

4.2.1. Blockchain

A decentralised and distributed system of all transactions in a specific business segment is what is known as blockchain technology. To create a chain, data and transaction-related information are collected in blocks attached to blocks that came before them. Blockchains guarantee information availability and visibility and can co-locate with all parties involved in commercial activities (Fill and Mejer, 2020). With the widespread adoption of cryptocurrencies, their impact on the buying and selling processes in the logistics sector will soon become evident. It is important to investigate the effects of cryptocurrencies on fiscal policies in this context (Abed, 2023). Furthermore, the effects of the innovations brought by blockchain on stock indices, including publicly traded logistics companies (Kendirli et al., 2022), and on other financial markets need to be thoroughly researched (Kendirli and Şenol, 2021).

4.2.2. Drons

Amazon, Google, and DHL are just a few of the big names in the business who have been experimenting with drones for commercial use recently. Intralogistics processes, logistics activity tracking, and final consumer commodity delivery are the three main areas where drones are expected to find widespread use. Drones can streamline intralogistics operations within the same building by transporting goods between production units, delivering essential spare parts, and moving goods from warehouses to retail sections. Drones

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have many potential applications in inventory management, reception area car monitoring, and building and equipment condition assessment (Vergouw et al., 2016).

4.2.3. Automatic Guidance Vehicle

Pallet trucks, trolleys with extra forks, light goods vehicles, assembly line vehicles, trailer-pulling tractors, vehicles for unit loads, and other specialised vehicles are examples of automated guided vehicles used in logistical operations. Traditionally, these vehicles have been employed for complex jobs; they allow loads and equipment to be transported automatically. Automated guided vehicles lower labour costs, improve productivity, safety, and job quality, and lessen the possibility of damage and human error in logistical operations (Berman et al., 2009).

4.2.4. Wireless Sensor Networks

Systems with a sensor and a wireless communication network are known as wireless sensor networks. Sensors are used to identify things and their physical attributes, such as equipment, traffic infrastructure, locations in warehouses and sales facilities, containers, and the qualities of commodities. These networks are primarily used in logistics for assessing truck loads, quality control of items through data processing from sensors, and enhancing worker safety and health conditions through work clothing with integrated sensors (Pottie, 1998).

4.2.5. Augmented Reality

By removing barriers between the actual and digital worlds, augmented reality gives users access to more information from the latter and a more expansive picture of reality. An extended reality image is produced for the user by the gadget by presenting layers of digital data. Devices include laptops, tablets, smartphones, eyewear, and more. Thanks to augmented reality, the correct data is accessible when and where needed. One example of an augmented reality application in logistics is the usage of smart glasses for various warehouse jobs such as picking, sorting, and packaging; intelligent forklift and vehicle transportation; and wise product distribution to end users through the use of smart glasses (Carmigniani and Furht, 2011).

4.3. Advantages of Logistics 4.0

Speed, reliability, operating costs, efficiency, standardisation and workload are among the advantages that Logistics 4.0 will bring. Speed: Drone or delivery robot-operated delivery services will make deliveries much faster. Reliability: Utilizing robots in storage will ensure high reliability in warehouse processes. Operating Costs: Processing costs will be reduced thanks to inventory tracking and replenishment systems that use smart sensors. Efficiency: With Blockchain technology (transactions are possible to complete in a fraction of the time thanks to the elimination of intermediaries and the reduction of formalities), efficiency will be increased in container loading and transportation. Standardisation: With the use of technology, logistics processes will become standard. Workforce: Work done by autonomous machines and robots will save labour (Tang and Veelenturf, 2019:4-5).

5. Conclusion And Recommendations

Industry 4.0 will transform by profoundly impacting every aspect of the production system, ranging from products, services, and business models to organizational structure and infrastructure. Companies that don't put money into pilot programs and learn about these new technologies run the danger of falling behind the competition and not being a part of the manufacturing revolution happening right now. Within the framework of Industry 4.0 components, supply chain management is also profoundly impacted by Industry 4.0, which

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aids in cost reduction, increases productivity, efficiency, and flexibility, and improves product customization. Thus, supply chains have taken a big step towards digitalization, automation, and agility in their operations.

Logistics 4.0 refers to the logistics industry's implementation of the Industry 4.0 framework. This is about digitalization, automation and data integration of logistics processes. Industry 4.0 technologies enable real-time monitoring and control of logistics operations. This allows inventory management, transportation planning, and delivery processes to be managed more effectively. Logistics 4.0 offers significant opportunities to provide better service to customers. Optimizing delivery processes, shortening delivery times and providing more accurate information to the customer increases customer satisfaction.

The logistics industry has permanently changed and adjusted to the demands of the populace, as well as to the latest advancements in technology and other obstacles. Companies must comply with the logistics 4.0 concept, which includes high implementation risks, large sums of money, specific infrastructure needs, updated training requirements, and competent employees. The company must be committed to the changes, determined to enhance technology and procedures and create its own intellectual resources to support the changes to satisfy these objectives and overcome any potential obstacles.

Industry 4.0 technologies provide the opportunity to monitor logistics processes in real-time using monitoring systems such as IoT sensors and RFID. This helps understand where products and inventory are located, reducing the risk of loss or damage and increasing the reliability of the logistics network.

Logistics 4.0 offers a vital strategy and opportunity to create a more competitive, efficient and innovative structure in the logistics industry. Consequently, logistics firms should put money into and use these technologies.

In addition, logistics operations that use AI (artificial intelligence) and machine learning can further improve prediction and decision-making capacities. With the use of AI, massive amounts of data can be analyzed to improve inventory management, demand forecasting, and route optimization. Over time, machine learning algorithms can decrease expenses and enhance service quality by adapting to changing conditions and improving operational efficiency. Organizations that take use of these cutting-edge technology will have a leg up when it comes to meeting client needs and responding to changes in the market.

Logistics 4.0 also places a premium on cybersecurity. The likelihood of cyberattacks is rising in tandem with the digitization of logistics activities. To safeguard confidential information and keep the supply chain running smoothly, strong cybersecurity measures must be in place. In a highly linked and competitive business, investing in cybersecurity is essential for protecting the company's operations and gaining the trust of consumers and partners.

As logistics undergoes transformation under Industry 4.0, sustainability will play an increasingly important role. More and more, businesses are concentrating on finding ways to lessen their impact on the environment and adopting green logistical practices in response to mounting regulatory demands and public concern. To reach sustainability targets, technology like electric cars, drones that can fly themselves, and a ledger system to record emissions can be useful. Adopting these advances allows logistics organizations to meet the demands of environmentally conscious consumers while also boosting operational efficiency and contributing to environmental conservation (Ulusoy and Abed,2023).

In addition, the more interdependent and complicated global supply chains have become, the more supply chain management in an Industry 4.0 setting needs to change to accommodate them. Transparency and visibility in the supply chain can be greatly improved with the use of advanced analytics and big data. When all parties involved share data in real-time, it improves coordination, shortens lead times, and lessens disruptions. An enormous competitive advantage will accrue to businesses that master the art of data-driven decision-making.

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Integrating and collaborating throughout the supply chain is also crucial. Suppliers, manufacturers, and consumers are all able to communicate and work together more efficiently thanks to Industry 4.0. Digital ecosystems and collaborative platforms facilitate information sharing, which in turn increases responsiveness and encourages innovation. To successfully traverse the intricacies of contemporary supply chains, companies should put resources into establishing solid alliances and making use of collaborative technologies.

The human element is still crucial in the world of Industry 4.0. Skilled workers are required to oversee and improve these technologies, even when automation and digitization revolutionize procedures. In order to make sure that employees can use Industry 4.0 equipment effectively, it is critical to train and upskill them continuously. In the face of constant technological improvements, companies that invest in their people and encourage innovation will be better equipped to withstand and adapt.

Finally, the logistics industry stands to gain a great deal from the arrival of Industry 4.0 and its logistics-related implementation, Logistics 4.0. Efficiency gains, happier customers, and a leg up in the competition are in store for businesses that fully embrace digitalization, automation, and data integration. Companies need to invest in cutting-edge innovation, guarantee cybersecurity, and adhere to sustainable practices if they want to make it through this shift unscathed. When these technologies are seamlessly integrated, logistics will be able to face the challenges of the future with greater innovation, resilience, and sustainability.

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