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Review Article

Extensive Literature Review On Green Logistics 5.0 With Ai Integration

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A B S T R A C T

Green Logistics 5.0 combines cutting-edge technologies like blockchain and artificial intelligence with a human-centred approach to create a logistics industry that is sustainable, strong, and efficient. This evolution concentrates on supply chain optimisation for environmental benefits through methods including route optimisation, packaging waste reduction, and warehouse efficiency enhancement, while allowing human workers to collaborate with these intelligent technologies. A review of logistics 5.0 and its effects on international supply chain systems has been attempted in this research. To examine the effects of logistics 5.0 on highly sustainable systems, data was collected from a variety of publications. Green Logistics 5.0 emphasises a human-AI synergy where technology supports and enhances human decision-making, as opposed to the automation-focused Logistics 4.0. Instead of having AI-powered systems replace workers, this entails retraining them to collaborate with them.

Keywords: Logistics 5.0, AI Integration, Sustainable Development, Warehouse, AI Synergy

Introduction

Logistics 5.0 stresses integrating technology with a human-centeredhuman-centred,, sustainable, and resilient strategy, going beyond the automation-focused Logistics 4.0. Building on the digital foundation of Logistics 4.0, it emphasizeshuman-centred,emphasises human-machine collaboration, sustainability, and resilience in supply chains to better meet consumer expectations and social purposes. The three primary pillars—sustainability, resilience, and human-centricity—are bolstered by cutting-edge technologies like block chainemphasisesblockchain,, artificial intelligence, and machine learning.

Important blockchain,1.1. Importantelements of Logistics 5.0

Logistics 5.0 places more emphasis on integrating technology with a human-centered1.1. Importanthuman-centred,, sustainable, and resilient strategy than Logistics 4.0, which was primarily concerned with automation. It builds on the digital foundation of Logistics 4.0 by emphasizinghuman-centred,emphasising human-machine collaboration, sustainability, and resilience in supply chains to better meet consumer wants and social objectives. The three key pillars—sustainability, resilience, and human-centricity—are backed by cutting-edge technology like block chainemphasisingblockchain,, artificial intelligence, and machine learning.

Logistics 5.0 enablingblockchain,Enabling technologies

- **Artificial intelligence (AI):** used for autonomous decision-making, planning optimization,Enablingoptimisation, and predictive analytics, including operational modifications in real time.
- By utilizingoptimisation,utilising data to guide decisions, machine learning enables continuous process improvement.

- The Internet of Things (IoT) links sensors and gadgets to give the data streams needed for a transparent and intelligent supply chain.
- By offering the infrastructure for data processing and storage, cloud computing makes it possible for more businesses to utilizeutilisingutilise cutting-edge technologies.
- **Block chainutilise Blockchain:** uses an immutable, decentralizedBlockchain:decentralised ledger to increase efficiency, security, and transparency.

What sets it apart from Logistics 4.0?

The main focus of logistics 4.0 is automating and digitisingdecentralised logistics through the use of technologies like cloud computing and the Internet of Things. Logistics 5.0 places more emphasis on intelligent human-machine collaboration than just automation, as opposed to logistics 4.0. It also includes the essential components of human-centricity and sustainability.

Everything You Must Know About Logistics 5.0

The marketplace for business in the digital age is always evolving. Because of this, many businesses struggle to maintain their leadership positions in their respective fields. The industrial and logistical sectors have seen the biggest changes in recent years. Innovative technologies such as artificial intelligence (AI), machine learning (ML), and big data are currently employed in this sector to meet the ever-changing demands of customers. Artificial intelligence, robots, lean manufacturing, and language processing are all backed and controlled by quickly developing technology. The COVID-19 epidemic also presented a number of challenges for the sector. However, Logistics 4.0 technology was introduced in response to the requirement to effectively manage and deal with the interruptions during COVID-19. Logistics 5.0 is being used by businesses to move towards sustainability.

The impact of COVID-19 on industrial change

The outbreak had a significant impact on the logistics services industry, resulting in significant and lasting changes. The changes and overhauls brought about by the pandemic's effects on the logistics sector's landscape should be considered while creating a new environment for the sector. Because people couldn't leave their houses during the outbreak, there was a greater need for logistics. This led to a number of issues, including enhanced security measures, staff renewals, delays, disruptions, and shortages of containers. These issues hastened the release of Logistics 4.0. Businesses in this sector have been compelled to invest in innovation and technology in order to become more resilient and competitive.

Logistics 5.0 and the forthcoming era

For the impending Logistics 5.0 era of digital transformation, all supply chain participants—manufacturers, suppliers, vendors, distributors, logisticians, and even customers—must get ready. Businesses are getting ready for this new wave of change by finishing their software needs inside this framework. Logistics 5.0 is expected to become the standard in the marketplace in the next years; therefore,, businesses need to get ready for a future when they will function considerably differently from how they do now. How receptive to innovation a company is will determine how well it integrates Logistics 5.0. The cost of state-of-the-art technology has significantly decreased. Small businesses are therefore able to invest in information centres and these technologies without having to manufacture the required hardware.hardware.

How does AI make Logistics 5.0 possible?

Real-time adaptation: AI agents continuously review real-time data to start quick reactions, such as rerouting shipments to avoid traffic congestion or adjusting manufacturing schedules in response to current sales. Strategic advantage: AI helps businesses to adapt to changing market conditions, boost competitiveness through forecasting, and continuously improve processes like demand forecasting and inventory control. Simplified problem-solving: AI models, which frequently require less specialised data and techniques, are better at generalising knowledge and solving complicated issues than traditional methods.

Evolution of Logistics 5.0:

Logistics 5.0 is a new approach to supply chain management that incorporates cutting-edge technology like artificial intelligence (AI) while placing a major focus on resilience, sustainability, and human-centred collaboration. Unlike Logistics 4.0, which was mostly concerned with automation, Logistics 5.0 aims to improve efficiency, flexibility, and ethical standards by fostering a symbiotic interaction between intelligent systems and humans.

AI's place in Logistics 5.0:

By offering cutting-edge capabilities throughout the supply chain, artificial intelligence (AI) is the fundamental technology that makes Logistics 5.0 possible.

- **AI-driven autonomy:** Rather than merely reporting problems, intelligent systems are now able to take coordinated action on their own. For example, they can reroute shipments quickly to avoid traffic or replenish inventories when a popular item runs low.

- **Intelligent forecasting:** AI makes very accurate demand predictions by utilising market trends, historical data, and outside variables like the weather. This ensures optimal inventory levels and lowers overstocking expenses.
- **Predictive maintenance:** AI examines sensor data from automobiles and machinery to foresee probable malfunctions. This minimises expensive and inconvenient downtime by enabling proactive maintenance.
- **Route optimisation:** AI determines the best delivery routes in real time, taking into account factors like fuel usage, traffic, and weather. This cuts carbon emissions, expedites delivery, and lowers operating costs.
- **Improved human-robot cooperation:** Cobots, or collaborative robots, assist human workers in automating physically demanding and repetitive jobs. This allows human workers to concentrate on addressing more intricate, strategic, and imaginative problems.
- **Sustainable operations:** AI reduces waste through improved packing and inventory management, optimises fleet routes to consume less fuel, and enables intelligent energy use in warehouses, all of which contribute to the achievement of environmental goals.
- **Hyper-personalisation:** By examining consumer data, artificial intelligence (AI) enables businesses to predict client demands and make real-time service adjustments, providing ever-more-responsive and customised services.

AI has the potential to generate virtual "digital twins" of the whole supply chain. By simulating various situations and disturbances, these twins can improve risk management and resilience planning.

Advantages of AI-Powered Logistics 5.0

- **Increased productivity and lower costs:** AI minimises labour, fuel, and inventory expenses by streamlining procedures, automating jobs, and optimising resources.
- **Increased resilience and adaptability:** AI makes a supply chain more flexible by employing predictive analytics, which enables it to react swiftly to interruptions, changes in the economy, and evolving consumer demands.
- **Improved sustainability:** By cutting waste, increasing energy efficiency, and reducing carbon emissions associated with transportation, AI-powered optimisation lessens its negative effects on the environment.
- **Improved working conditions:** Human employees' safety, well-being, and job satisfaction are increased when they work with AI to solve repetitive, tiresome, and hazardous activities.
- **A better experience for customers:** Transparent, real-time tracking, more precise delivery estimations, and customised services are made possible by AI, which boosts client loyalty and happiness.

Literature Review

Several academic studies on AI integration in Logistics 5.0 with relation to a global situation are covered in this area.

Salwaldamia et al. [2024] Supply Chain 5.0, which integrates cutting-edge digital technologies like artificial intelligence, the Internet of Things (IoT), blockchain, and analytics, signifies a paradigm shift in logistics and operations. This study examines how Supply Chain 5.0 may revolutionise supply chain management procedures by maximising effectiveness, adaptability, and responsiveness. This study emphasises how crucial it is to overcome these obstacles in order to fully reap the rewards of Supply Chain 5.0, which will boost resilience, sustainability, and competitiveness in the global economy.[1]

Bernardo Nicoletti et al. [2024] The study integrates the green approach in Logistics 5.0 using foundation models. A more sustainable and affluent future is the result of such integration, which is also innovative in logistics. This paper may systematise the environmental framework of the logistics industry, raise its social responsibility, and guarantee its long-term economic viability by utilising foundation models and integrating sustainable concepts. One of the biggest difficulties of our time is creating environmentally friendly logistics, which is addressed in this paper. The framework can be used by logistics firms.[2]

Chih-Hung Hsu et al. [2024] Industry 4.0 has made great strides in smart logistics, but it hasn't yet adequately addressed issues like resilience, sustainability, and human centricity. These issues with Industry 4.0 are addressed and improved by the rise of Industry 5.0. However, research on how Industry 5.0 might propel the evolution of smart logistics is currently lacking. This study creates a strategy roadmap that provides a solution to this problem in order to close the gap.[3]

Alexander Samuels [2025] As Industry 4.0 gives way to Industry 6.0, this study looks at how supply chain management (SCM) is using artificial intelligence (AI). Enhancing supply chain sustainability, encouraging human-centred collaboration, and increasing operational efficiency are the main goals. It is becoming more and more important for industries to adopt AI technologies that enhance operational resilience and decision-making while guaranteeing sustainable practices. AI integration in SCM fosters resilience to disturbances in addition to increasing operational sustainability and efficiency. Academics and practitioners looking to optimise supply chain operations using AI technologies from Industry 4.0 to Industry 6.0 will benefit greatly from the insights from this review.[4]

Hajar Fatorachian et al. [2023] The combination of Industry 5.0 and the globalisation process of supply chain

management has become a key factor in determining the competitiveness and sustainability of businesses worldwide in the quickly changing global business environment of today. This essay explores the critical role that Industry 5.0 will play in changing supply chain management dynamics globally. Industry 5.0 is the most recent stage of the ongoing industrial revolution, defined by the smooth integration of cutting-edge technologies, including cyber-physical systems, artificial intelligence (AI), big data analytics, and the internet of things (IoT). Because of the enormous levels of connectedness, intelligence, and automation it fosters throughout industrial processes, this change goes beyond conventional limits.[5]

Hamideh Nazarian et al. [2024] Many supply chain (SC) managers have found the transformative potential of Industry 5.0 (I5.0) to improve SCP to be an appealing topic. Three important aspects are highlighted in this study as it examines the significant effects of I5.0 on SCP: responsiveness, visibility, and efficiency. Enhancing visibility results in increased responsiveness and efficiency, since it reveals the dynamic interaction between different aspects.[6]

B. Andres et al. [2017] As the follow-up to Industry 4.0, Industry 5.0 is distinguished by its emphasis on sustainability, resilience, and human-machine collaboration. In order to assist supply chain (SC) logistics, this study explores the enabling technologies that help both I4.0 and I5.0 evolve. The concepts of Logistics 5.0 are defined in the paper. In order to support decision-making based on the data, the traditional logistics framework requires creative solutions based on cutting-edge I5.0 technologies that can capture and process large datasets. Using real-world SC Logistics 5.0 scenarios, the study evaluates the application status of various enabling I5.0 technologies. Additionally, the article highlights prospective areas for each I5.0 technology and outlines research gaps in the assessed technologies. The purpose of this guidance is to guide future research towards the useful implementation of technologies to support Logistics 5.0.[7]

Laura Monferdini et al. [2025] By utilising technology like the Internet of Things, artificial intelligence, and big data, as well as emphasising human-centred, robust, and sustainable systems, Industry 4.0 and Industry 5.0 present both opportunities and problems for the logistics sector. Clarifying how Industry 4.0 and Industry 5.0 interact and what it means for Logistics 4.0 and Logistics 5.0 is crucial. Descriptive and bibliometric analyses of articles obtained from the Scopus database are presented in this study, with an emphasis on the subjects just discussed. The findings demonstrate that businesses using Industry 4.0 technologies see notable increases in traceability and customer satisfaction. This basis is expanded upon by Industry 5.0, which emphasises the integration of humans and technology.[8]

Maja Trstenjak et al. [2022] The function of humans in the larger system is being given extra attention with the introduction of Society 5.0 for the sustainable future. In a similar vein, Logistics 5.0 has been introduced in its theoretical framework, after Industry 5.0 as a concept. In order to define an accurate and optimal strategic plan for the shift to the new Logistics 5.0 concept, an implementation model based on decision support systems will be established in this article. The priorities of Logistics 5.0 elements (from five groups—green warehousing, green transportation, green packaging, infrastructure and organisation, and human resources) for the best implementation are the model's output data. These are based on three objectives that businesses hope to accomplish in the future: initial investment, return on investment time, and implementation and exploitation complexity.[9]

Nazaré Toyoda Machado et al. [2025] As an extension of Industry 4.0, Logistics 5.0 is examined in this article, with a focus on how logistics management incorporates cutting-edge technology like big data, IoT, and artificial intelligence. It suggests a particular methodology for measuring Logistics 5.0 maturity that is divided into five levels: initial, repeatable, defined, managed, and optimised. These levels assess process management, analytical capability, sustainability, change management, and technical preparedness.[10]

Benjamin Burroughs et al. [2020] The combination of aesthetic, economic, and cultural elements that we refer to as enchantment leads to ways that logistical services enhance products beyond conventional utility tradeoffs. We explore the ways in which enchantment could be expressed digitally through mediated consumption (as opposed to physical consumption), taking into account the cultural practices and affordances of the platforms and venues. We investigate the ways in which enchantment can transpire in digitally mediated shopping contexts through a number of case studies. According to our case studies, enchanted digital logistical channels expand on the value-creating capabilities of traditional logistics by generating enchantment-providing consumption scenarios that are surprising and intriguing, imply perceived scarcity, and use social media to reach customers in various ways.[11]

Martin Johannes du Plessis et al. [2025] The link between humans and machines is becoming more and more popular. By outlining several use examples, this study explores the possible benefits and effects of applying artificial intelligence (AI) in the freight logistics sector. It looks at how the logistics sector can use AI and data to make better decisions that will increase its sustainability on all fronts—economic, social, and environmental. A thorough literature analysis, facility visits, interviews with subject matter experts, and generative AI were all part of the research technique. The SLR revealed that no comprehensive explanation of

AI application cases in freight logistics is provided by any peer-reviewed literature.[12]

Angappa Gunasekaran et al. [2007] Since the worldwide market and the Internet, and especially electronic commerce (e-commerce), third-party logistics (3PL), a relatively new business, have grown in popularity. Companies are under increased pressure to enhance their product and service delivery performance to customers due to global competition. Companies have outsourced their logistics services, such as packing, warehousing (inventory management), and delivering goods to customers, in an attempt to enhance the quality of delivery services.[13]

Abderahman Rejeb et al. [2020] This paper examines studies on the Internet of Things (IoT) in logistics and supply chain management (SCM). To unbiasedly and analytically uncover the advancements in IoT research in the context of supply chain management and logistics, a comprehensive review and bibliometric analysis were carried out. First, 807 journal articles published over a two-decade span were chosen for study. After that, the publications were examined using bibliometric criteria such as the year of publication, authors, institutions, and sources. The relevant literature was clustered using a term co-occurrence network. The review's and bibliometric analysis's findings show that the logistics and supply chain management communities have given IoT research a lot of attention.[14]

Dmitry Ivanov [2022] Industry 5.0 is a set of technological advancements and organisational concepts that combine to create and oversee supply chains and operations as robust, sustainable, and human-centred systems. Although the broad idea of Industry 5.0 has been developed, nothing is known about how it will affect operations and supply chains in the future. This article helps to conceptualise Industry 5.0 from a feasibility standpoint. Using the viable supply chain model, the reconfigurable supply chain, and human-centric ecosystems as lenses, we contextualise an Industry 5.0 framework. Our research reveals the key elements that define Industry 5.0 as a framework for technology and organisation.[15]

Samir Saidi et al. [2020] The relationship between transport, logistics, FDI, and economic growth in emerging nations between 2000 and 2016 is examined in this paper. The Middle East, North African, and Sub-Saharan countries (MENA-SSA); East Asian, Pacific, and South Asian countries (EAPSA); and European and Central Asian countries (ECA) were the three sub-panels of a worldwide panel data collection that included 46 developing nations.[16]

Dingfu Jiang [2020] A "smart" modern society has gradually emerged across all spheres of life due to the Internet of Things' and cloud computing's extensive applicability, quick development, and collaboration of new ideas and technology. These technologies have slowly made their way into the smart city space. In addition to operating in an extremely inefficient and laborious manner, the traditional urban system—which has been in place since antiquity—has not successfully shared or connected its information with other systems.[17]

Cheng Feng Wu et al. [2024] Information and physical movements are important factors in determining consumers' intents to make purchases when they browse for consumer electronics online. In order to investigate these elements, this study integrates logistical service quality with the Technology Acceptance Model and analyses the interaction between e-commerce businesses and customers. The main focus is on how consumers' decisions to make online purchases are influenced by information and physical flows, which are essential components of the supply chain. Using SHapley, a machine learning method and structural model The Technology Acceptance Model and logistics service quality are thoroughly examined using additive explanations, which are used to analyse the data. The most significant aspects influencing consumers' purchase intention are attitude, perceived usefulness, and informativeness, according to the research.[18]

Chiara Cimini et al. [2022] As operators continue to play a crucial role in the factories of the future, it will become more and more crucial in the coming years to rethink manufacturing and logistics systems from a human-centred perspective. This will encourage a balanced use of automation and digital technologies to enhance the special and irreplaceable capabilities of operators. Contributing to the primary developing research streams on human-technology integration in next-generation manufacturing and logistics systems is the goal of the sixteen papers included in this special issue.[19]

Kadir Alpaslan Demir et al. [2019] "The Future". These days, some futurists even speculate on the theme of the fifth industrial revolution. A few ideas for Industry 5.0 exist. The co-working of humans and robots is one new theme. Significant progress has been made in robotics and artificial intelligence (AI) research in recent years. There are now reasonably priced robots available on the market for a variety of uses. both at work and in our personal life. One intriguing illustration of this emerging trend is the testing of driverless vehicles in traffic. Robots or AI applications have their own employee records in some firms.[20]

Martin Johannes du Plessis et al. [2025] The human–machine interface is increasingly attracting attention. This paper investigates the potential value and impact of using Artificial Intelligence (AI) in the freight logistics industry by defining various use cases. It explores how the logistics industry can use data and AI to improve its economic,

social, and environmental sustainability through better decision-making. The research methodology comprised generative AI, facility visits, interviews with subject matter experts, and a systematic examination of the literature. None of the peer-reviewed literature provides a thorough explanation of AI application cases in freight logistics, according to the SLR.[21]

Seetha Raman et al. [2018] Big data is the subject of this study since it presents fresh possibilities, value addition, and operational excellence for current supply chain procedures. US, Middle Eastern, European, Asian, and Australian employees of international corporations participated in a poll. Statistical analysis of the survey data was done using structural equation modelling. The use of big data technologies will soon become the norm in the sector and can provide businesses with significant financial and value-added benefits. The Supply Chain Operations Reference (SCOR) model is described in a new way by this study by combining SCM and big data.[22]

Laura Monferdini et al. [2025] Logistics is facing both opportunities and problems as a result of Industry 4.0 and Industry 5.0, which emphasize human-centered, resilient, and sustainable systems while utilizing technology like the Internet of Things, artificial intelligence, and big data. Clarifying how Industry 4.0 and 5.0 interact and what it means for Logistics 4.0 and 5.0 is crucial. With an emphasis on the subjects just discussed, this study offers descriptive and bibliometric analyses of publications that were obtained from the Scopus database. The findings indicate that businesses use Industry 4.0 technologies to significantly increase customer satisfaction and traceability. Building upon this framework, Industry 5.0 emphasises the integration of humans and technology.[23]

Praveen Kumar Reddy Maddikunta et al. [2022] As the next industrial evolution, Industry 5.0 aims to create resource-efficient and user-preferred manufacturing solutions by combining the creativity of human professionals with accurate, intelligent, and efficient machinery. Industry 5.0 is anticipated to benefit from a plethora of exciting technology and applications that will help boost productivity and provide customised products on demand. Our goal in this study is to present a survey-based tutorial on the possible uses and auxiliary technologies of Industry 5.0 in order to give a very first discussion of the topic.[24]

Nilofer Jefroy et al. [2022] The emergence of the concept of Industry 5.0 has advanced the research frontier of the technology-focused Industry 4.0 to a smart and harmonious socio-economic transition driven by both humans and technologies, where the role of the human in the technological transformation is primarily focused on. This is due to the importance of human centricity, resilience, and sustainability. The effects of disruptive technologies on intelligent logistics operations in Industry 4.0 are covered in several studies. The features of smart logistics in Industry 5.0 with regard to four areas—intelligent automation, intelligent devices, intelligent systems, and intelligent materials—are then demonstrated through a comprehensive content analysis.[25]

Chih Hung Hsu et al. [2024] Industry 4.0 has made great strides in smart logistics, but it hasn't yet adequately addressed issues like resilience, sustainability, and human centricity. These issues with Industry 4.0 are addressed and improved by the rise of Industry 5.0. However, research on how Industry 5.0 might propel the evolution of smart logistics is currently lacking. This study creates a strategic roadmap that provides a solution to this problem in order to close the gap. An extensive literature analysis with an emphasis on content is the first step in the research process, which identifies 13 critical enablers that are essential to achieving smart logistics in Industry 5.0.[26]

Guilherme F. Frederico [2021] This paper aims to explain the implications of the Industry 5.0 phenomenon in the context of supply chains. Evidence from the state of knowledge related to this issue was gathered using a methodical literature review approach. There is a significant gap in the supply chain field's Industry 5.0 techniques, according to the results. In the literature, 41 publications—including journal and conference papers—have been located. The data analysis discovered 19 (19) terms by grouping them into four (4) clusters.[27]

Bader Alojaiman [2023] Production lines have faced difficulties in recent years due to unforeseen events. The most recent worldwide COVID-19 pandemic is one prominent example. The virus has not only affected society but also ruined the conventional industrial production structure. Industry 4.0 necessitates flexibility in response to evolving requirements. Industry 5.0, the following movement, has surfaced in recent years, though. People and machines work together more in Industry 5.0, which has a more coordinated strategy than Industry 4.0. Industry 5.0 enhances Industry 4.0 with a human-centred approach to increase resilience and sustainability.[28]

Saeid Nahavandi [2019] The rapidly evolving and increasing digital technologies and AI-based solutions make it harder and harder to stay at the top. The fields of modern manufacturing, mass customisation, and technology are rapidly changing. Because of advancements in artificial intelligence and brain-machine interface, robots are becoming even more significant to humans.[29]

Vural Özdemir et al. [2017] AI-powered driverless cars and automated supermarkets with collaborative robots (cobots) operating without human oversight have spurred new discussions about how Big Data and omics implementation

science will be affected by extreme automation fuelled by the Internet of Things (IoT), artificial intelligence, and Industry 4.0. (1) Broadband wireless internet access; (2) miniature sensors implanted in both inanimate and alive items, such as the milk carton in your smart refrigerator or the house cat; and (3) artificial intelligence and cobots that interpret sensor-collected Big Data are the foundations of the Internet of Things.[30]

Monica Cugno et al. [2021] There hasn't been much research focus on how incentives and barriers affect the relationship between performance and receptivity to Industry 4.0. Therefore, using a mixed-techniques approach, this research investigates this link. While a quantitative analysis using an OLS regression-based path analysis is conducted on a representative sample of 500 local manufacturing units in Piedmont (a region of Northern Italy), a qualitative analysis using in-depth interviews and multiple case studies identifies significant barriers and incentives.[31]

Roberta Stefanini et al. [2022] Modern industries must adapt to new technology developments. Industrial processes are becoming more automated and networked as a result of the introduction of new tools and technology known as "Industry 4.0". Laws and international conferences, like the 2030 Agenda, require businesses to be more sustainable in the interim. This study examines the sustainability of 4.0 technologies in the food industry by analysing existing research that focuses on a potential connection between these two subjects. Using the Scopus scientific database, a literature analysis was conducted to find English-language publications worldwide.[32]

Kasrim [2025] The goal of Society 5.0 is to create a super-smart society that incorporates cutting-edge technology like robotics, artificial intelligence (AI), and the Internet of Things (IoT) into every facet of life, including logistics and distribution. This essay examines how smart distribution, which improves speed, efficiency, visibility, safety, and environmental impact, might transform next-generation logistics.[33]

Wenwen Chen et al. [2024] The application of artificial intelligence (AI) to logistics optimisation has drawn a lot of interest lately, especially in relation to sustainability standards. The many AI models and algorithms used in logistics optimisation are summarised in this article, with an emphasis on sustainable methods. Generative models, machine learning approaches, metaheuristic algorithms, and their synergistic combinations with conventional optimisation and simulation methods are among the topics covered.[34]

Chetna Chauhan et al. [2022] Academic literature at the intersection of supply chain collaboration (SCC) and sustainability has increased as a result of the worldwide push towards sustainable development. In order to comprehend how SCC can help achieve the more general Sustainable Development Goals (SDGs), the current research attempts to map this expanding body of literature. The study maps important issues at the nexus of SCC and sustainable development using a systematic review of the literature (SLR). The report offers fresh perspectives on the field of SCC for sustainable development based on nine major issues.[35]

Smail Benzidia et al. [2021] In recent years, scholars and practitioners have been more interested in big data analytics and artificial intelligence (BDA-AI) technologies. The advantages of BDA-AI in the supply chain integration process and its effect on environmental performance, however, have not been thoroughly studied empirically. By including BDA-AI and establishing digital learning as a moderator of the green supply chain process, we expanded the organisational information processing theory to close this gap.[36]

Shaolong Tang et al. [2015] One of the most often used inventory control systems in practice, the periodic inventory review system, is used in this study to investigate the problem of reducing emissions by decreasing shipment frequency. In order to depict the business-as-usual scenario, we first create a benchmark model. This model is then further developed into a carbon emission reduction model by adding a constraint that represents the emission reduction % target.[37]

Zhu Liu et al. [2021] Carbon dioxide (CO_2) emissions from China are currently the highest in the world. As a result, China is crucial to the mitigation of climate change worldwide. To make decarbonisation possible, policies and commitments are needed. The main characteristics of China's CO_2 emissions, its methods for reducing them, and its accomplishments in reaching climate goals are outlined in this perspective. China has significantly reduced CO_2 emissions; by 2020, carbon intensity had dropped by 48.4% from 2005 levels, meeting goals set forth in the Nationally Appropriate Mitigation Actions and Nationally Determined Contributions.[38]

Robert N. Boute et al. [2021] Applications of artificial intelligence (AI) are becoming ubiquitous in supply chain management and logistics. There are new opportunities to enhance supply chain decision-making due to the ubiquitous availability of data and ongoing advancements in processing power. Applications for digital logistics or the Internet of Things' ability to connect assets are two possible sources of data. Additionally, AI can help automate well-defined workflows.[39]

Andreia G. Pereira et al. [2020] Industry 4.0 aims to transform industrial production through improved operational efficiency and the creation of new services, goods, and

business models. Unlike traditional forecasting, it allows real-time production planning and dynamic optimisation. Industry 4.0's tools and technical advancements will play a major part in raising society's standard of living and enabling people to be happier, more motivated, and contented while also having more free time.[40]

Imran Ali et al. [2025] Although Industry 5.0 research has attracted a lot of attention because of its rapid growth, the literature is still dispersed across different disciplines. Our comprehensive analysis of 98 publications from 2014 to 2024 yields important conclusions: a lack of a cohesive definition, which led us to suggest a more inclusive definition of Industry 5.0; gaps in rigorous quantitative, qualitative, and simulation-based research; a dearth of theory-based research; and three central themes of the current Industry 5.0 research—human centricity, resilience, and sustainability.[41]

Shruti Agrawal et al. [2024] The next industrial revolution, known as Industry 5.0 (I5.0), aims to achieve even more user-preferred and resource-efficient manufacturing and supply chain solutions by utilising human intervention in conjunction with intelligent, logical, and smart equipment. This article's primary goal is to examine I5.0 technologies in supply chains that are impacted by disruptive events like pandemics, conflicts, or climate change. A methodical literature study approach was used to comprehend the current understanding related to this issue.[42]

Aditya Akundi et al. [2022] The phrase "industry 4.0", which was developed to allude to the fourth industrial revolution, describes a higher degree of automation for operational productivity and efficiency through the integration of an industry's virtual and physical worlds. Industry 5.0 was created to solve personalised production and empower people in manufacturing processes since Industry 4.0 was unable to meet the growing need for personalisation. When the term "industry 5.0" first emerged, there were differing opinions about what it meant and how humans and machines could coexist.[43]

P.O. Skobelev et al. [2021] Industry 4.0, which blends the actual world with its "virtual twins", is the fourth industrial revolution that the world is currently experiencing. Beyond this philosophy is the man with his intelligence, inventiveness, and determination. A new paradigm for Industry 5.0 is now visible. In order to increase man's potential and bring him back to the "Centre of the Universe", it entails artificial intelligence infiltrating human daily lives and their "cooperation".[44]

Farhan Aslam et al. [2020] Innovation is essential for competitive advantage and economic growth in today's corporate climate, which is marked by fast technical breakthroughs and globalisation, aided by the Internet of Things and the Industry 5.0 phenomenon. However, the lack of a workable innovation management framework is causing many organisations to struggle with its actual execution, making the idea illusive rather than convincing.[45]

Zeinab Sazvar et al. [2021] In order to create a sustainable and resilient supply chain, this study presents a multi-objective mathematical model that takes into account both tactical and strategic decision levels. When the company is particularly susceptible to operational and disruption threats, the approach is to proactively plan for an ideal configuration to meet consumer demands. In contrast to earlier research, we use an optimisation framework to design a supply chain network that is resilient to the demand side by applying capacity planning in terms of redundancy.[46]

Payman Ahi et al. [2015] Finding and evaluating the metrics that have been reported in the literature on sustainable supply chain management (SSCM) and green supply chain management (GSCM) is the aim of this study. A structured content analysis of 445 articles published until the end of 2012 was used to determine the measures. A total of 2555 distinct metrics were found. There is disagreement on how performance should be evaluated in various areas, as evidenced by the fact that most measurements were only used once.[47]

Zehao Huo et al. [2020] The manufacturing sector is going through previously unheard-of transformations in the era of Industry 4.0 due to the quick development and use of technologies like the Internet of Things (IoT), big data, and artificial intelligence (AI). In this regard, inventory management procedures across all industries now heavily rely on data mining technology. This study investigates the significant influence of data mining on the effectiveness of inventory management. Data mining helps businesses estimate demand, optimise inventory levels, and increase supply chain transparency by utilising sophisticated analytics and machine learning algorithms.[48]

Sergey Evgenievich Barykin et al. [2023] The creation of contemporary logistics systems necessitates cutting-edge solutions for concurrently accomplishing ambitious commercial objectives and sustainable development goals. The difficulty of integrating digital technologies into social life, especially in smart cities, merits particular consideration in this regard. The shortcomings in the design, control, and efficiency evaluation of digital tools in the logistics of smart cities are highlighted by the varied application of Industry 4.0 doctrine and digital shadow penetration to all domains of socioeconomic systems.[49]

Baha M. Mohsen [2020] Artificial Intelligence (AI) has the ability to completely transform a number of commercial processes. AI can be used to find supply chain inefficiencies, optimise logistics and transportation routes, and analyse

data to forecast demand. This may result in shorter lead times, lower costs, and better responsiveness to shifts in demand. Using the Scopus database, this study examines and evaluates AI applications in supply chain management (SCM).[50]

Case study

Logistics 5.0 is a paradigm change that combines human-centred, sustainable, and resilient concepts with cutting-edge technology like artificial intelligence (AI), robotics, and the Internet of Things (IoT). Research and reports show how businesses are putting important concepts into practice, even if comprehensive, real-world case studies on full-scale Logistics 5.0 are still developing because of its recent creation.

This case study is on "Global Retail Co.", a hypothetical international e-commerce business that is aggressively moving towards Logistics 5.0.

Background of the company: Global Retail Co. is a major online retailer with an extensive worldwide logistics network. The business is constantly under pressure to lower expenses, speed up deliveries, and enhance sustainability because it operates in a very competitive sector.

Initial challenge (Logistics 4.0 mindset): Global Retail Co. had effectively automated numerous procedures using a Logistics 4.0 strategy. Warehouse robotics, sensor-based tracking, and sophisticated analytics for route optimisation were all deployed. Its system was still mainly reactive, though, with managers waiting for data to make choices and human workers concentrating on monotonous duties. The business's sustainability initiatives were supplemental rather than essential to its operations.

The move to Logistics 5.0: Global Retail Co. started the change to Logistics 5.0 in reaction to the COVID-19 pandemic and growing customer demand for ethical practices. Three fundamental pillars were involved: resilience, sustainability, and human-centric design.

Design that is human-centred

Global Retail Co. changed their perspective on employees from one of expense to one of investment.

- **Collaborative robotics (cobots):** These days, robots assist human pickers rather than taking their place. Cobots at fulfilment centres reduce physical strain and injuries by lifting and moving large shelves straight to human workers. The more difficult jobs of inspecting, packing, and labelling, where dexterity and judgement are essential, are handled by human workers.
- **Improved workspaces:** The corporation installed ergonomic workstations, improved insulation, and more effective lighting in its warehouses.

Employee upskilling: Workers' attention was diverted from repetitive physical labour to higher-level supervision and problem-solving as they were retrained to handle and cooperate with the new technologies.

Sustainability as a fundamental tenet

- Instead of being a stand-alone project, sustainability was immediately included in the logistical strategy. AI-driven optimisation: In order to lower fuel usage and transportation emissions, AI systems optimise routes. Additionally, they make the most of storage space in order to minimise the overall operating footprint of the business.
- **Green warehousing:** AI modifies temperature, lighting, and equipment use in real-time according to occupancy and activity. To cut down on energy use, the company also adopted sensor-activated doors and more effective heating and cooling systems.
- **Eco-packing:** By using predictive analytics to optimise box sizes and materials for every shipment, packaging waste is reduced. Additionally, the business put in place a mechanism to incentivise suppliers to return packing.

Adaptability via intelligent systems

Global Retail Co. created a supply chain that is more flexible and resilient to shocks.

- **Real-time visibility:** To get rid of data silos and guarantee real-time accuracy throughout its network, the company built a strong IoT and cloud computing architecture.
- **Predictive analytics:** AI-driven analytics use data analysis to forecast possible supply chain interruptions, enabling managers to foresee risks and create adaptable, proactive solutions.
- **Decentralised Autonomous Operations (DAOs):** The business uses decentralised autonomous systems and blockchaintechnology to facilitate more adaptable, secure, and responsive operations. This guarantees that even in the event of network disruptions, operations will continue.

Results and lessons learnt

Global Retail Co. benefited greatly from the shift to Logistics 5.0:

- **Enhanced productivity and efficiency:** While intelligent optimisation decreased errors and operating expenses, human-robot cooperation accelerated fulfilment. Enhanced safety and morale among employees: A safer, more ergonomic workplace resulted from the emphasis on employee well-being. Overall job satisfaction and retention increased as a result of workers feeling more appreciated and invested in their positions.

- **Enhanced sustainability:** In keeping with its corporate responsibility objectives and appealing to customers who care about the environment, the company decreased waste and its carbon footprint. Increased adaptability: The supply chain's competitive position was strengthened by its ability to react quickly and nimbly to disruptions thanks to AI-driven predictive capabilities.

Conclusion

Logistics 5.0 is a final framework that integrates technology and human collaboration to create resilient, human-centred, and sustainable supply chains. It shifts from a model of total automation to one in which technology enables human workers to become less task-orientated and more strategic; key outcomes include the development of robust supply chains, an emphasis on the long-term welfare of workers, and a fundamental integration of sustainability into all aspects of the logistics process.

Key lessons of Logistics 5.0

Human-machine Collaboration: Rather than substituting humans, Logistics 5.0 employs AI and other technologies to perform monotonous jobs, freeing up people for complex problem-solving and ongoing development.

- **Resilience:** By utilising data to forecast demand, control inventory, and instantly adjust to changes, it creates stronger supply chains that are more resilient to disturbances.
- **Sustainability:** By maximising energy use, minimising waste, and cutting emissions through more intelligent routing and packing, the strategy places a high priority on environmental impact.
- **Competitiveness and profitability:** Logistics 5.0 helps companies stay profitable and competitive while simultaneously accomplishing social and environmental objectives by increasing efficiency and adjusting to market shifts.
- **Focus shift:** It signifies a significant change in perspective, going beyond Logistics 4.0's strictly technical emphasis to a more comprehensive approach that places equal emphasis on people, the environment, and technology innovation.

Future Challenges

Some of the impending challenges for Logistics 5.0 include the high cost of technology investment, the need for substantial workforce reskilling to deal with advanced automation, and the integration of new systems with complex legacy infrastructure. Other challenges include ensuring data security and privacy in an interconnected world and developing a truly sustainable, human-centred approach alongside technological progress.

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