

A Systematic Literature Review of Digital Supply Chains and Logistics 4.0 for Sustainability and Circular Economy

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Abstract

This study presents a systematic review of the role of key technologies in advancing sustainable logistics and supply chain management. Specifically, it explores the integration of Industry 4.0 (I4.0), logistics 4.0, and digital supply chains, focusing on technologies such as artificial intelligence (AI), augmented reality (AR), big data analytics (BDA), block-chain, cloud computing (CC), industrial internet of things (IIoT), machine learning (ML), robotics, virtual reality (VR), and internet of things (IoT). The aim is to examine how these technologies contribute to green logistics (GL), green supply chain management, sustainability, and the circular economy (CE). Data were collected from the Scopus database, covering studies published between 2019 and 2024. A total of 1471 publications were initially identified, and 39 studies met the selection criteria. The PRISMA approach was employed for the systematic review, revealing that leading research on I4.0 is concentrated in top-tier journals, with a significant number of publications from Italy focusing on digitalization in the agriculture and food sectors. Systematic literature reviews and resource-based theory are predominant, yet there is a notable gap in aligning research with the United Nations Agenda 2030 Sustainable Development Goals (SDGs). This paper provides insights into technological adoption trends and offers recommendations for industry leaders seeking to enhance sustainability, eco-friendliness, and alignment with the SDGs within their supply chains.

Keywords: logistics 4.0; green supply chain management; artificial intelligence; cloud computing; internet of things; sustainable development goals; systematic literature review

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1. Introduction

Sustainable development goals (SDG) and national and international laws to protect the environment provide organizations with an opportunity to change their current business models and operations and move towards green, sustainable logistics, reducing carbon emissions, energy use, pollution, and waste to lower their carbon footprint [1]. Beyond the evident environmental benefits and compliance preparedness, these organizations may also gain new markets by adopting new and greener processes. These involves

opportunities related to brand reputation and customer loyalty development, as well as efficiency gains and cost savings associated with streamlined processes by the implementation of more efficient technologies [2]. This paradigm shift in organizations' operations implies holistically looking at businesses to boost economic performance while having a neutral or positive impact on the planetary ecosystem. A quarter of total greenhouse gas emissions (GHG) are caused by the transport sector [3]. The European Green Deal has set the European Union (EU)'s goal of reducing 90% of GHG emissions produced by the transport sector in the EU until 2050 [3]. Moreover, the European Climate, Infrastructure and Environment Executive Agency (CINEA) has funded 477.9 million euros in research activities focused on energy-efficient, less-polluting logistics and transport operations [3].

Organizations have moved from traditional processes such as paper-based record keeping, manual data entry, and face-to-face communication to digitalization involving Artificial Intelligence (AI), big data, Augmented Reality (AR), and Internet of Things (IoT). Advanced information technologies enable organizations to implement novel, greener, and sustainable practices in their Supply Chain (SC). The market value of the digital SC is expected to increase by 13.679 million by 2030, with a compound interest rate of 13.2%, instigated by COVID-19 [4,5]. According to a Gartner survey, 82% of CEOs have an interest in investing in digital capabilities in their organizations to improve SC efficiency [5,6]. However, 68% of chief SC officers had not yet developed their roadmap for the digital SC [5,6].

Digital (I4.0) technologies have been implemented in logistics, such as IoT, enabling organizations to track in real-time, interconnecting logistics operations, and monitoring [7]. AI optimizes logistics, SC planning, and real-time decision-making [7]. BDA has helped with inventory management, forecasting, and customer satisfaction through data-driven insights [8]. Robots are used for work efficiency, warehouse operations, and inventory tracking [8]. Blockchain technology is implemented for transparency, traceability, and documentation in logistics and SC [8]. CC plays a vital role in integration and collaboration for data sharing among SC partners [9]. Digital platforms facilitate coordination and integrate logistics operations [9].

These digital technologies play a vital role in waste recycling [10], lowering the carbon footprint [11], increasing resource efficiency [12], contributing to the United Nations (UN) Agenda 2030 SDGs, and net-zero goals [13]. These technologies are also reducing environmental pollution [14] and air pollution [15], contributing to innovative water management [16], and the circular economy (CE) [17], as well as aligning with environmental policies [18].

In the framework of the UN Agenda 2030, the SDGs were established in 2015, directed to all countries, following the Millennium Assessment and the success of the original Millennium Development Goals, which were primarily targeted at developing countries. The SDGs comprise 17 interlinked sustainable development goals to address environmental, economic, and social challenges by 2030. Some of these goals can be particularly relevant for the logistics, SC, and manufacturing sectors. SDG 12 is focused on "responsible consumption and production", SDG 8 is focused on "decent work and economic growth", SDG 9 on "industry, innovation and infrastructure", and SDG 13 on "climate action", and in recent years, the SC and logistics have played a significant role in advancing the SDGs. For example, digitalization and logistics have been used to reduce overall carbon emissions and resource efficiency by supporting SDGs 9 and 13 [19,20]. However, detailed and further evidence on the impact of logistics, SC, and manufacturing on SDG goals remains mixed, with sector-specific information available.

Current literature indicates the importance of implementing advanced information technologies to protect the environment and make it more sustainable. However, there is a gap in the literature concerning how these emerging technologies, including AI, are

driving this transformation in I4.0, Logistics 4.0, and the Digital SC, and how these are being framed in the UN Agenda 2030 SDGs and sustainable development frameworks.

This study aims to fill this gap by examining and integrating the existing body of literature on European I4.0 [21], Logistics 4.0 [22], and Digital SC [23], focusing on the transformative role of emerging technologies such as AI for CE practices and sustainable performance [24], AR [25], BDA [26], Blockchain [27], CC [28], Digitalization [29], IIoT [30], ML [31], Robotics [32,33], VR [34], and IoT [35]. It also brings a new sustainable lens to these links, explicitly searching for them and identifying trends between the published literature and the UN Agenda 2030 SDGs to confirm whether these technologies drive advancements towards GL, sustainable SC management, and the CE.

Despite the increasing recognition of sustainability in SC management, the analysis highlights a critical gap: most researchers have not explicitly aligned their studies with the UN SDGs [36–38]. This indicates an urgent need for future research to incorporate SDG-driven frameworks to assess the real-world impact of digital transformation in SC.

This study provides an opportunity for future research on the adoption, implementation, and long-term effects of these technologies on the SDGs by identifying contemporary trends and patterns in the analyzed sectors and industries. The insights gained guide businesses, policymakers, and researchers in harnessing the potential of digital transformation to build eco-friendly, resilient, and sustainable SC and industries. Moreover, the study emphasizes the necessity of bridging the gap between technological advancements and sustainability objectives, ensuring that future innovations contribute meaningfully to the global transition toward a more sustainable and CE.

The purpose of this study is to examine how advanced information technologies are applied in the supply chain to achieve sustainable goals. This study will identify the gap among advanced technologies, sustainability, and SDGs in the supply chain and logistics context. To this end, the study aims to answer the following research questions.

RQ 1: How do emerging technologies transform supply chain and logistics to support sustainable outcomes?

RQ 2: How do existing academic studies explicitly align their work with the UN Sustainable Development Goals (SDGs)?

RQ 3: What are the prominent theories and methodologies used to analyze technological status and usage in sustainable supply chain and logistics?

RQ 4: What are the emerging themes, research gaps, and future research opportunities identified in this study?

This study is structured as follows: Section 2 outlines the Materials and Methods, detailing the research strategy used, inclusion and exclusion criteria, study selection, evaluation, and research tools. Section 3 presents the results of the bibliometric analysis, the theoretical frameworks used, and the methodological trends in the application of advanced information technologies across various sectors. Section 4 discusses the findings, offering explanations, justifications, and insights into the observed results. Finally, Section 5 concludes the study, highlighting its limitations and suggesting directions for future research to enhance the effectiveness of upcoming studies.

2. Materials and Methods

A systematic literature review (SLR) is a structured research method that follows a replicable process for selecting and analyzing studies through predefined scientific procedures [39,40]. The current study has employed the methodologies recommended by Kitchenham (2004) [41], Higgins and Green (2011) [42], and Moher (2009) [43], and has adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for reporting [44]. The PRISMA checklist is included in the supplementary material, aligned with the standardized PRISMA checklist [44]. Additionally, this

review has not been registered in PROSPERO because the study is not health related. Studies other than health studies do not need to be registered in PROSPERO [45]. This study ensures transparency by clearly outlining the search and screening process, as mentioned in Figure 1.

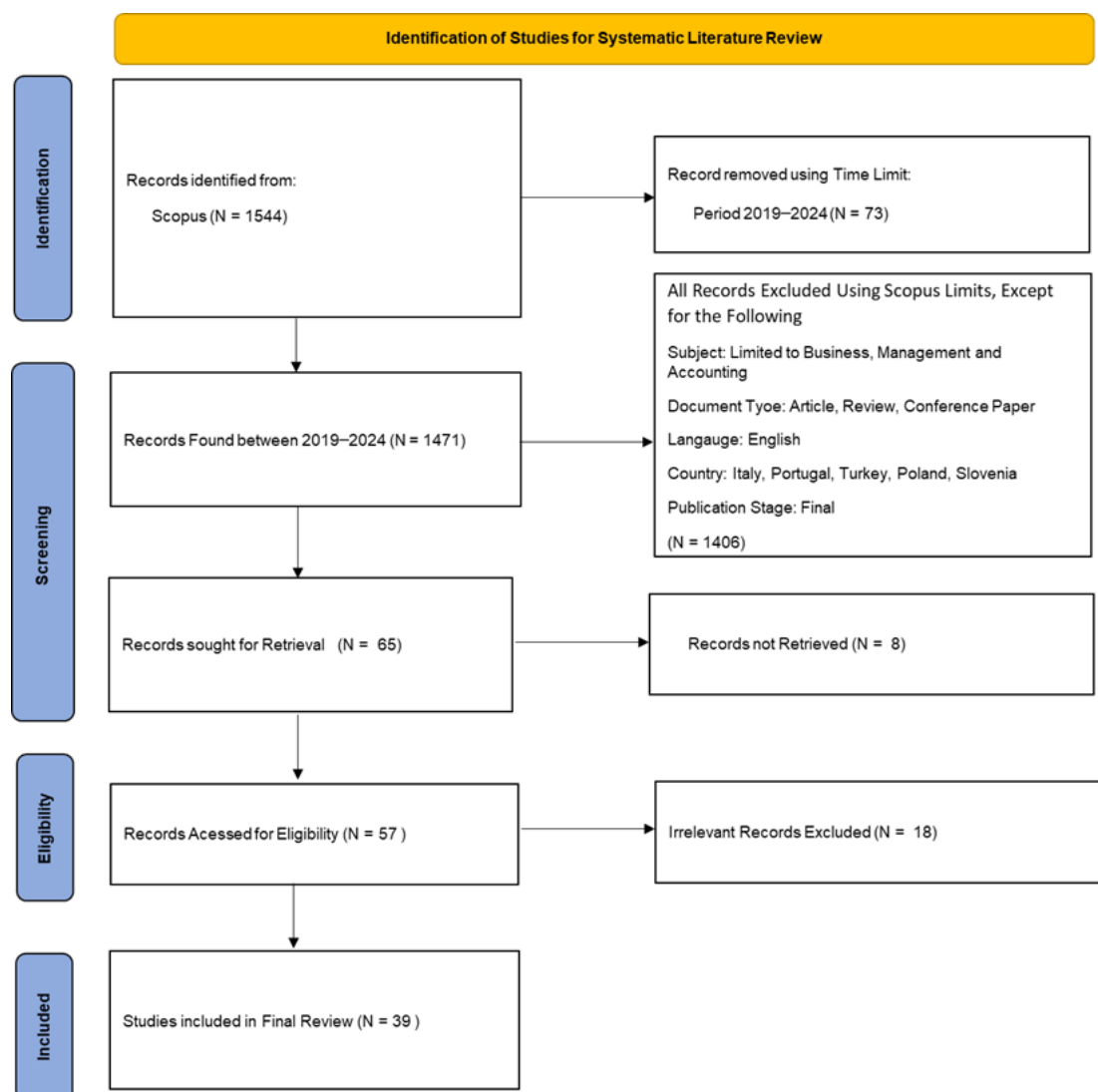


Figure 1. Prisma diagram for sustainable logistics 4.0.

2.1. Database Selection

In this study, the Scopus database has been selected. There are a few reasons for this choice. First, Scopus is the largest academic database, consisting of 20,346 journals, as compared to Web of Science, with 13,605 journals [46,47]. Second, Scopus database has the capability to do searches on specific subject areas such as Business, Management, and Accounting [48]. In contrast, IEEE Explore focused on technical and life sciences databases, while PubMed focused on life sciences. Third, the Canopus database has the capability to run advanced Boolean search, filtration, and export functions for transparent and reproducible systematic review [49].

2.2. Initial Search and Filtering

In the search strategy, two types of keywords have been considered. First, those that are related to digital technologies, such as big data and CC, while the second type of

keywords are related to the environment, such as green and sustainability, which are consistent with the previous literature [50–53].

The initial step in the search strategy was selecting the Scopus database as the source for these documents. The data were collected on 9 July 2024 from Scopus using the single complex query as (“Logistic 4.0” OR “Digital supply chain” OR “Industry 4.0”) AND (“Artificial Intelligence” OR “Augmented Reality” OR “Big Data” OR “Big Data Analytic” OR “Blockchain” OR “cloud computing” OR “digitalization” OR “Industrial Internet of things” OR “Internet of Things” OR “Machine Learning” OR “Robotic” OR “Virtual Reality”) AND (“circular economy “ OR “green logistic” OR “sustainability “ OR “green supply chain management”). Using this query, 1544 documents were found.

Scopus filters were used to select studies. The time frame was set from 2019 to 2024, to include the last 5 years. This choice was also linked to specific EU strategic decisions, as the European Green Deal was initiated in the year 2019, which has shaped the path to carbon neutrality and sustainability, and has started to focus on industry and transport for sustainable futures [54]. In addition, the COVID-19 pandemic, occurring after that in 2020, has disrupted the traditional supply chain and has boosted the digital adoption in supply chain and logistics [55]. The time limit has reduced the selected documents to 1471. In the next step, additional filters were: Limited to Business, Management, and Accounting subject areas, document type to Article, Review, and Conference paper in English, and publication to Final were selected [50,51]. After filtering on Scopus, 65 articles were selected and downloaded for further analysis.

2.3. Validation via Advanced Query

An advanced search query was then used to validate the previous search. It comprising TITLE-ABS-KEY ((“Logistic 4.0” OR “Digital supply chain” OR “Industry 4.0”) AND (“Artificial Intelligence” OR “Augmented Reality” OR “Big Data” OR “Big Data Analytic” OR “Blockchain” OR “cloud computing” OR “digitalization” OR “Industrial Internet of things” OR “Internet of Things” OR “Machine Learning” OR “Robotic” OR “Virtual Reality”) AND (“circular economy “ OR “green logistic” OR “sustainability “ OR “green supply chain management”)) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA, “BUSI”)) AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “re”) OR LIMIT-TO (DOCTYPE, “cp”)) AND (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (AFFILCOUNTRY, “Italy”) OR LIMIT-TO (AFFILCOUNTRY, “Portugal”) OR LIMIT-TO (AFFILCOUNTRY, “Turkey”) OR LIMIT-TO (AFFILCOUNTRY, “Slovenia”) OR LIMIT-TO (AFFILCOUNTRY, “Poland”)) AND (LIMIT-TO (PUBSTAGE, “final”)). A final number of 65 documents resulted from this process, which matched exactly and validated the previous simple search.

2.4. Geographical Scope

The scope of the study was limited to five countries: Poland, Turkey, Italy, Slovenia, and Portugal. These countries were not selected arbitrarily; they were involved in the funding project associated with this research. Furthermore, socio-economic reasons are also behind this selection. First, the selected countries have varied GDP and economic spectra, such as Italy has a 2.37 trillion USD GDP, and Slovenia has 0.07 trillion USD in 2024 [56]. This heterogeneity in economic growth indicates constraints and capabilities for implementing new technologies in logistics and SC. Second, the World Bank’s 2023 Logistics Performance Index (LPI) indicates differences in logistics capabilities across countries. Italy has a 3.9 value in timeliness tracking, indicating good performance in delivering products and tracking logistics. While Portugal has a 3.6 score in timeliness and logistics competence and quality, it shows that it has focused more on product competence, quality, and timely delivery. Poland has a 3.9 score in timeliness and a 3.8 score in tracking,

and timeliness is the key indicator of its logistics. Slovenia's 3.6 score in infrastructure and 3.4 score in international shipments indicate that Slovenia is more concerned with developing the logistics infrastructure and international shipments. Turkey has a 3.6 score in timeliness, a 3.5 score for logistics competence and quality, and tracking [57].

The Digital Economy and Society Index (DESI) was developed to assess digital maturity across European countries and comprises a set of indicators. In this study, small and medium-sized enterprises with at least a basic level of digital intensity were used, with the unit of measure being the % of enterprises in 2024. Italy has scored 60.69%, Portugal has scored 53.61%, Poland has scored 50.04%, and Slovenia has scored 50.36% [58], but Turkey has not yet been included in this index. All the selected countries showed a shift towards digitalization in organizational processes to transform their businesses. Fourth, these five countries were also selected based on geographical, sectoral, and strategic considerations. European economies vary in terms of industrial development, sustainability, and digital transformation across SC and logistics. Situated at the intersection of Southern and Eastern Europe, Italy and Poland play crucial geoeconomic roles within the EU. They serve as important centers where many of the largest manufacturing and logistics companies on the continent focus their activities to take advantage of access to important markets and international SC. Portugal and Slovenia are small but growing in investment in digital infrastructure. Turkey is in Europe, but it has created a logistics bridge between Europe and Asia, along with other European countries. Including Turkey creates a broader insight beyond the EU 27.

2.5. Study Selection and Data Extraction

In this study, two independent reviewers have screened the studies at two levels. First, screening was based on the title, abstract, and keywords. In the second stage, reviewers studied full texts to align the studies with the research questions. Only studies that focused on AI, AR, Big data, blockchain, CC, digitalization, IIoT, IoT, ML, Robotic, and VR technologies in Logistics 4.0, Digital supply chain, and I4.0 to achieve CE, GL, Sustainability, and GSCM were included. A total of 65 documents were selected after applying all filters in the Scopus database. In the inclusion criteria, the title, abstract, and keywords of 65 papers were analyzed to find relevant technologies implemented in digital SC or logistics 4.0 to achieve sustainability or CE, and 18 documents that were irrelevant to the study were excluded. Additionally, 8 papers were unavailable to the authors or lacked open access. Therefore, 39 articles were selected for full-text review for further analysis.

2.6. Inclusion and Exclusion Criteria

The applied inclusion criteria include the timeframe between 2019 and 2024, published in the subject area of Business, Management, and Accounting. The document types are articles, reviews, and conference proceedings in English. Italy, Portugal, Turkey, Poland, and Slovenia were included; the characteristics of the selected studies are presented in Table S1 in the Supplementary Materials. In contrast, if the article were published at any other time, in any other geographical location, in any other document type, or in any other language, these factors would be excluded.

2.7. Data Analysis Tools

The analysis and calculations were performed using Microsoft Excel 365, and VOSviewer 1.6.20 was used to generate the network diagram. The word cloud was generated using a free online tool (<https://wordcloud.online/> (accessed on 23 August 2025)). Microsoft Word 365 was used for report writing, and Zotero was used to arrange citations

and references. Grammar has been checked using the Grammarly Premium version to remove grammatical mistakes from the final report.

3. Results

3.1. Bibliometrics Assessment

In this section, a bibliometric analysis was performed, and publications were assessed for impact (quartile and journal impact factors) and geography (first author country of work). The quartiles and impact factors of the journals that published them are examined to evaluate the impact of this body of research and the topic analyzed in this study. The quartiles of the journals have been found through ScimagoJR [59]. A total of 39 studies from 2019 to 2024 met the inclusion criteria, which were used for further analysis. The results in Figure 2 indicate that most studies (77%) have been published in Q1 journals, highlighting the importance, demand, and impact of advanced information technologies in supply chain and logistics, while considering green and sustainability in the literature. The lowest ratio (10%) was reported in Q3; no papers have been published in Q4 journals.

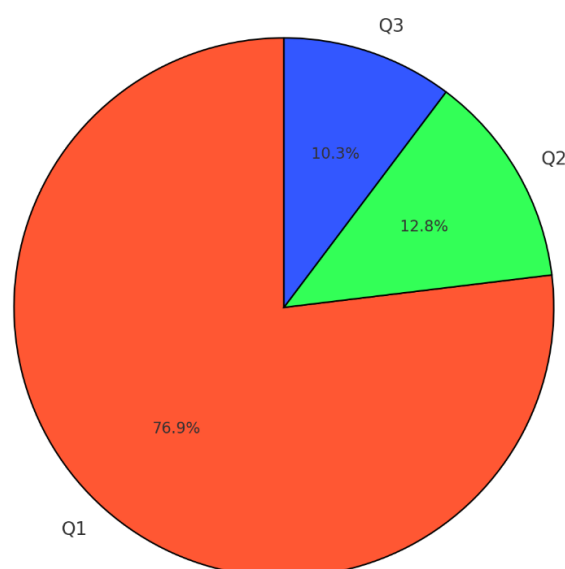


Figure 2. Journal Quartiles of included publications in this systematic review study.

The highest-scoring journal was the Journal of Cleaner Production, which published 9 papers on the focused study area between 2021 and 2023. Moreover, the sharp growth in publications between 2021 and 2023 was reported in the literature. This growth has drawn attention to digital transformation, which can be integrated into the European Green Deal. Technological Forecasting and Social Change published four papers between 2021 and 2023, and Business Strategy and The Environment published three documents between 2022 and 2023, all of which were very reputable Q1 journals. The complete name of the journal, with the time frame from 2020 to 2024, and the total number of publications in each journal and each year are mentioned in Table 1.

Table 1. Distribution of included publications per journal name and year.

Journal	2020	2021	2022	2023	2024	Total	Studies
Journal of Cleaner Production		3	1	5		9	[37,51,60–66]
Technological Forecasting and Social Change		1	1	2		4	[67–70]

Business Strategy and the Environment			2	1		3	[36,71,72]
International Journal of Production Research				1	1	2	[73,74]
Sinergie Italian Journal of Management	1					1	[38]
Management and Production Engineering Review	1					1	[75]
Tehnicki Glasnik				1		1	[76]
Engineering Economics	1					1	[77]
Production Planning and Control				1		1	[78]
European Management Journal				1		1	[79]
Competitiveness Review: An International Business Journal				1		1	[80]
IEEE Transactions on Engineering Management					1	1	[81]
Journal of Quality in Maintenance Engineering			1			1	[82]
International Journal of Innovation Studies				1		1	[83]
Management Decision	1					1	[84]
International Journal of Operations and Production Management					1	1	[85]
Serbian Journal of Management			1			1	[86]
International Journal of Physical Distribution and Logistics Management				1		1	[87]
Sustainable Futures			1			1	[22]
Virtual Economics				1		1	[88]
Technology in Society			1			1	[89]
Business Information Review	1					1	[90]
Engineering Management Journal				1		1	[91]
Cleaner Logistics and Supply Chain					1	1	[92]
Journal of Air Transport Management			1			1	[93]
Grand Total	2	7	9	17	4	39	

In the next step, the geographical distribution of these studies was determined to analyze potential biases and identify which countries are conducting the most studies. To start this analysis, the countries of the corresponding authors were examined. The information regarding countries has been collected from the corresponding author's affiliation. The maximum number (18) of authors was from Italy, followed by Turkey with four authors. Portugal has three authors, Poland and the United Kingdom have two, and the remaining countries have only one. The corresponding author's country distribution is depicted in Table 2. The results indicated that most of the studies from the selected five countries (Italy, Turkey, Portugal, and Poland) were consistent and aligned with the geographical scope of this study. Moreover, the results showed international collaboration from Asia and North Africa, highlighting the EU's leadership in sustainability, but they also created a geographical imbalance in the study of the regional perspective.

Table 2. Geographical distribution of corresponding authors of included publications.

Country	2020	2021	2022	2023	2024	Total
Italy	1	3	4	7	3	18
Turkey				4		4
Portugal		1		1	1	3
Poland	1			1		2
United Kingdom		1	1			2
Brazil			1	1		2
Finland		1				1
Slovenia				1		1
Serbia			1			1
India		1				1
Lithuania			1			1
China				1		1
Russia				1		1
Morocco			1			1

3.2. Technological Applications and Sectoral Focus

To analyze the technological trends under study and implemented in I4.0, digital SC, and logistics 4.0, this study searched the selected publications for specific keywords related to these technologies and cross-referenced them with the mentioned applications. It has also analyzed whether these trends varied when multiple sectors (I4.0, digital SC, and logistics 4.0) were the focus of the publications. The results obtained are presented in Table 3. Most papers were published in 2023, demonstrating a very recent acknowledgement of these technological trends in industry. Most publications focused on I4.0, and the most prominent technology mentioned was digitalization. In contrast, logistics 4.0 was the least focused area, indicating an even more recent awareness of the potential of such technological trends for this component, and the IoT or IIoT was the least considered technology.

Table 3. Digital technological trends in industry 4.0, digital supply chain, and logistics 4.0 across included publications in this systematic review.

Industrial Revolution	Technology	2020	2021	2022	2023	2024	Total
Industry 4.0	Multiple Technologies	1	2	4	7	3	17
	Digitalization		2	1	5	1	9
	Blockchain		2	1	1		4
Multiple Operations	Industrial Internet of Things	1					1
	Blockchain				1		1
	Multiple Technologies			1	3		4
	Internet of Things			1			1
Digital supply chain	Blockchain		1				1
Logistic 4.0	Digitalization			1			1

In the next phase, this study analyzed the technological trends across and between industrial sectors. The results in Table 4 indicate that the most prominent sectors are agriculture and food, while digitalization is the most notable technology mentioned. Other industrial industries included automotive, gas and oil, pharmaceutical, and construction.

Table 4. Crossing between industrial sectors and major technological trends across the included publications in this systematic review.

Sectors	Blockchain	Digitalization	Industrial Internet of Things	Internet of Things	Multiple Technologies	Total
Uncategorized	1	3	1		8	13
Agriculture and food	1	2		1	3	7
Manufacturing	1	2			3	6
Supply chain and logistics	1				4	5
Multiple Sectors		1			1	2
Electronics	1					1
Small and Medium Enterprises		1				1
Automotive Industry					1	1
Economic, Technological		1				1
aerospace					1	1
Fashion Industry	1					1

3.3. Theories and Methodologies

This study has identified the selected publications and the key theories used in each work to determine current trends in theoretical framing and the theories applied in these fields. The theoretical lens, from the perspective of technologies and sectors found in the body of literature, is mentioned in Table 5.

Table 5. The intersection among theories, sectors, and technology across included publications in this systematic review.

Theory	Sector	Blockchain	Digitalization	Industrial Internet of Things	Internet of Things	Multiple Technologies	Total
Knowledge-based View	Supply chain and logistics					1	1
Mathematical Graph Theory	Sector not mentioned					1	1
Resource-Based View	Manufacturing					1	1
Social Capital Theory	Fashion industry	1					1
Theory of Planned Behavior	Electronics	1					1
	Aerospace					1	1
	Agriculture and food	1	2		1	3	7
	Automotive industry					1	1
Other	Multiple Sectors		1			1	2
	Economic, Technological		1				1
	manufacturing	1	2			2	5
	Small and Medium Enterprises		1				1

Supply chain and logistics	1			3	4
Other	1	3	1	7	12

The same rationale was used to search for key methodologies in the analyzed publications. From a methodological perspective, the systematic literature review methods have been the most widely used in publications (nine). This was followed by seven case studies, six survey-based, and three bibliometric analyses, found in the selected literature. The methodological lens, from the perspective of technologies and sectors found in the body of literature, is mentioned in Table 6.

Table 6. The intersection between methodologies, sectors, and technologies across included publications in this systematic review.

Method	Sector	Blockchain	Digitalization	Industrial Internet of Things	Internet of Things	Multiple Technologies	Total
Bibliometric analysis	Uncategorized		1			2	3
	Aerospace					1	1
	Agriculture and food				1	1	2
Case study	Automotive industry					1	1
	Fashion industry	1					1
	Manufacturing		2				2
Contingent valuation	Electronics	1					1
Delphi Method	Supply chain and logistics					1	1
Econometric Method	Economic, Technological		1				1
Fuzzy decision support system	Manufacturing	1					1
Interview	Uncategorized			1			1
ISM-ANP approach	Agriculture and food		1				1
Multi-criteria decision making (MCDM), fuzzy Analytical Hierarchy Process (AHP)	Agriculture and food		1				1
	Supply chain and logistics					1	1
	Uncategorized	1					1
Narrative review	Agriculture and food					1	1
	Manufacturing					1	1
	Agriculture and food					1	1
Scientometric analysis	Uncategorized					1	1
Secondary data analysis	Multiple Sectors		1			1	2
	Manufacturing					2	2
	Small and Medium Enterprises		1				1

	Supply chain and logistics			1	1
Systematic literature review	Supply chain and logistics	1		1	2
	Uncategorized		2	5	7
Text classification	Agriculture and food	1			1

The relationship between methods and theories, with a time frame for publications, was also analyzed to determine whether any trends or preferences emerged. The results are presented in Table 7.

Table 7. The intersection between methodologies and theories with time across included publications in this systematic review.

Method	Theory	2020	2021	2022	2023	2024	Total
Bibliometric analysis	Mathematical graph theory				1		1
	Uncategorized				1	1	2
Case study	Social capital, resource-based		1				1
	Uncategorized		1	2	3		6
Contingent valuation	Theory of Planned Behavior		1				1
Delphi Method	Uncategorized				1		1
Econometric method	Uncategorized				1		1
Fuzzy decision support system	Uncategorized				1		1
Interview	Uncategorized	1					1
ISM-ANP approach	Uncategorized		1				1
Multi-criteria decision-making (MCDM), fuzzy Analytical Hierarchy Process (AHP)	Uncategorized			1	1		2
Narrative review	Uncategorized		1				1
Review	Uncategorized				2		2
Scientometric analysis	Uncategorized					1	1
Secondary data analysis	Uncategorized				1		1
	Knowledge-based view				1		1
Survey	Resource-Based View				1		1
	Uncategorized			3	1		4
Systematic literature review	Uncategorized	1	2	3	1	2	9
Text classification	Uncategorized				1		1

3.4. SDG Alignment

The present study has examined how Logistics 4.0 and advancements in Digital Technologies contribute to sustainability and CE, and how they relate to the UN Agenda 2030 and the SDGs. When analyzing this alignment, mixed trends were found amongst the green and sustainable SC literature. Most studies (21) have not mentioned nor aligned their methodologies with the 17 SDGs, even though their research focuses on circular or green practices that are inherently related to sustainability. However, this study also found that the trend toward including sustainable development frameworks and aligning studies with the SDGs appears to have increased since 2023. Moreover, the inclusion criteria for SDG alignment required explicitly mentioning the word and/or the SDGs in the study's text description. On the other hand, studies were not aligned with the SDGs if they

did not explicitly mention the SDGs in their publications. On the other hand, the studies were not aligned with the SDGs, as they did not explicitly mention them in their publications. Figure 3 illustrates the distribution of the selected publications according to whether they consider or do not consider the SDGs framework in their content analysis or methodological design. Moreover, the relationship between the SDGs and technologies is presented in Table 8.

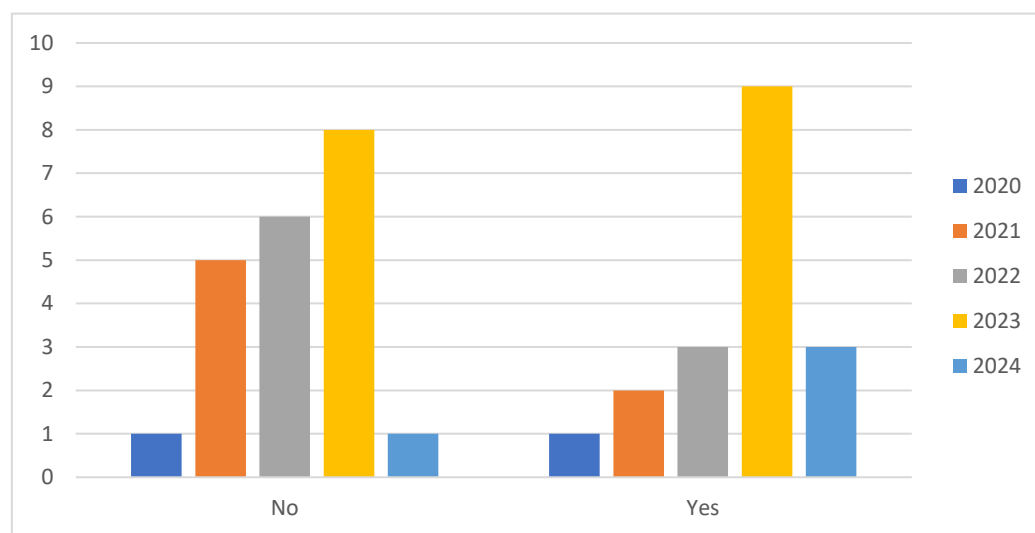


Figure 3. Results of the match between included publications per year and their alignment with SDGs.

Table 8. Relationship between SDGs and technologies.

Technology	No SDG Mentioned	Yes, SDG Mentioned	Total
Blockchain	3	3	6
Digitalization	4	6	10
Industrial Internet of Things		1	1
Internet of Things	1		1
Multiple Technologies	13	8	21
Total	21	18	39

3.5. Emerging Themes and Gaps

In this study, a network analysis using VOSviewer was also conducted on the selected studies to determine clustering and analyze potential trends reinforcement. The output is depicted in Figure 4. Five clusters were identified with this analysis. The red cluster focuses on digitalization, sustainable development, environmental technologies, climate change, and the food sector. This red cluster depicts the trend observed in digitalization and environmental technologies towards sustainable development to achieve social, economic, and environmental sustainability. The blue-colored cluster shows a clustering of SC management, sustainable SC management, agriculture, and IoT. Thus, the blue cluster supports the trend observed in the SC using IoT. The light green-colored cluster focuses on data analytics and digital technologies. Therefore, this light green cluster supports the use of digital technologies and data analytics across sectors. The purple-colored cluster has focused solely on the industrial revolution, making it a stand-alone trend. And finally, the dark green cluster is focused on I4.0, CE, blockchain, decision-making, sustainability, and digital transformation. This dark green cluster supports the link between I4.0 and achieving sustainability, and the CE with digital transformation to make rational manufacturing and industrial development decisions.

The network analysis has also demonstrated an interrelated connection among the clusters. The red color was more focused on digitalization and sustainable development clustering, while the blue color was concentrated on SC and IoT. This may imply that SC is the focal point for reducing carbon emissions through digital technologies to drive positive environmental change, aligning well with the SDG 13 goals. The green cluster focused on I4.0, blockchain, and the circular economy, which is directly interlinked with other (red, blue, purple, and dark green) clusters and with SDG 12, as it involves sustainable and responsible production and material flows. Moreover, the light green cluster appears focused on big data analytics across multiple disciplines, aligning with SDG 9 and the goal of achieving industrial innovation. It also aligned with the purple cluster, which is itself contributing to SDG8, aimed at improving SC efficiency and operational and organizational performance, thereby leading to economic growth.

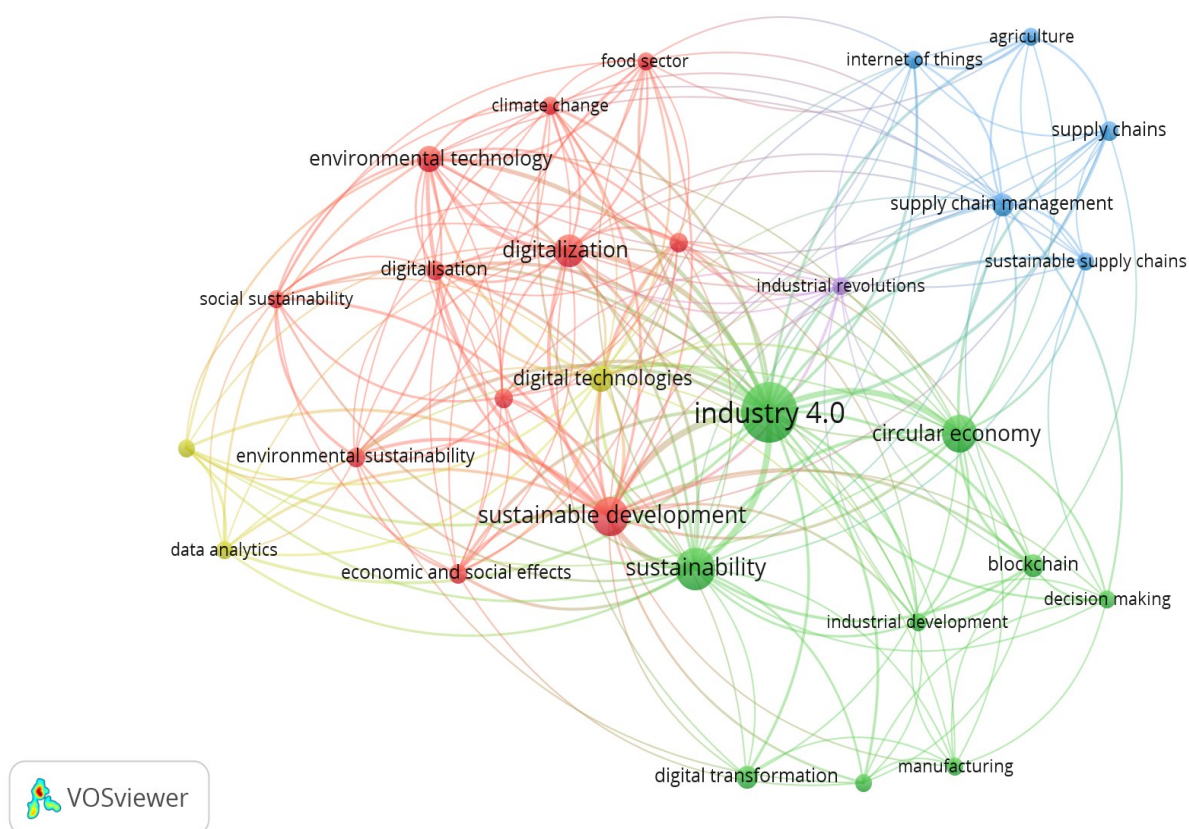


Figure 4. Keywords network analysis across included publications in this systematic review.

A list of antecedents, independents, moderators, mediators, and dependent variables was recorded in Excel. Then, this information was used on the website (<https://wordcloud.online/>) to provide the graphical representation of the word cloud found in this literature search [53]. This method assessed which variables are most prominent in the literature. The results demonstrate that most of the literature has focused on the SC, technology, performance, innovation, reduction, emissions, CE, integration, and risk. The resulting word cloud is depicted in Figure 5.

The word cloud showed that the most prominent variables in SC are performance, integration, and technology. These variables represent the operational side of SC rather than a holistic approach to sustainability, suggesting that the industry is still prioritizing economic values over genuine sustainability principles. The sustainability concepts seem to be applied when they can represent an economic or efficiency (and therefore economic again) gain in the SC. Moreover, the operational SC efficiency can create a competitive

[27], CC [28], digitalization [29], IIoT [30], ML [31], robotics [32,33], VR [34], and IoT [35] in driving GL [94] green SC management [95,96], sustainability [97,98], and CE [24]. The present study has also focused on aligning selected studies with sustainable development and SDGs by determining their links with CE practices, GL, or green SC management.

Data were collected on 9 July 2024 from the Scopus database in the 2019–2024 timeframe to encompass the last 5 years of research. 1471 documents were retrieved. After analyzing all the inclusion criteria, 39 documents were selected and explored in depth. The results showed that most studies were published in Q1 journals in 2023. The most prominent journals were the *Journal of Cleaner Production*, with an impact factor of 9.7, and *CiteScore*, with a score of 20.4, and the *Association of Business Schools (ABS)*, which ranks second. *Technological Forecasting and Social Change* has an impact factor of 12.9, a *CiteScore* of 21.3, and is ranked third by ABS. Additionally, *Business Strategy and the Environment* have an impact factor of 12.5 and a *CiteScore* of 22.5, and ABS ranked 3, highlighting the importance of the topic. The growing trend from 2019 to 2024 in the number of papers and the higher impact of these publications predict a continued increase in publications in 2025 and beyond.

The study has focused on Italy, Portugal, Turkey, Poland, and Slovenia, as these five countries were the focus of the project funding this research and also provide a combination of geographical, sectoral, and strategic considerations, as stated in Section 2.3. European economies vary in terms of industrial development, sustainability, and digital transformation across SC and logistics. Italy and Poland host the largest manufacturing and logistics companies in Southern and Eastern Europe. Portugal and Slovenia are small but also growing in investment in digital infrastructure and digital services. Turkey is in Europe and has created a logistics bridge between Europe and Asia. Including Turkey in this study provides broader insights beyond the EU 27. During the data collection, these countries were filtered as geographically concentrated areas. The results showed that the corresponding authors from Italy were the top producers of research publications in this area of expertise, with 18 of the 39 papers corresponding to them. Turkey had 4 publications, followed by Portugal with 3, Poland with 2, and only 1 corresponding author from Slovenia. Except for Italy, in all the other countries, there is still a significant opportunity to further research these topics and to increase the adoption and implementation of I4.0 and Logistics 4.0 technologies to improve their countries' profiles in CE practices and sustainability.

The selected five countries have contributed to increased digital logistics and overall sustainability in these areas. In Italy for instance, the Port of Genoa and the Port of Trieste both have innovative, Port of Genoa and the Port of Trieste both have innovative, e Port of Genoa and the Port of Trieste both have innovative, the Port of Genoa and the Port of Trieste both have innovative, and strategically ideal ports. These ports implemented advanced information technologies such as AI and robotics for digital transition and socio-economic empowerment in the Port of Genoa [99]. Moreover, the Port of Trieste has launched the digital freight corridor to streamline logistical operations [100]. In Portugal, for example, the Port of Sines has also implemented the one-window port operations platform, an innovative setting that increases port efficiency and productivity and contributes to enhancing its decarbonization and sustainability. Digitalization in Sines Port has also contributed to digital logistics [101,102].

Poland has implemented advanced information technologies, especially focused on I4.0, interlinked with manufacturing [103], and intelligent systems in logistics [104]. Slovenia, on the other hand, has focused more on circular economy practices in transport [105], and E-logistics [106]. Moreover, Turkey has harmonized their transport and maritime policies with the EU [107,108]. Additionally, the digital revolution and technological advancement have improved the logistics in Turkey [109].

4.2. I4.0 Technologies in SC and Logistics (RQ1)

The current study has focused on the transformative role of emerging technologies, such as digitalization in manufacturing [75], agriculture [22,64], to achieve a CE, and sustainability for small and medium enterprises [83]. Blockchain, a prominent SC and logistics technology, has shaped the CE [36]. Moreover, IoT has focused on sectors such as the agriculture sector to fasten their route to sustainability [69]. Additionally, the most prominent result of our study was the indication that multiple technologies (more than one technology or a combination of two or more technologies) were found in the SC and logistics sector for the CE [77,78,87] and sustainability [76]. The multiple technologies category was also used and implemented in the manufacturing industry for the CE [71] and sustainability [62,72]. Adopting and implementing advanced information technologies in SC logistics has transformed organizational processes into more sustainable ones, directly linked to the SDGs. However, in the literature analyzed, most studies are not yet aligned with, or mention, the SDGs in their research [36–38]. However, the trend seems to have been changing since 2023, and authors are now starting to align their studies with the SDGs, indicating the vital role of technology in making organizational operations more efficient and contributing to sustainability.

The fourth industrial revolution has focused on the adoption and implementation of advanced information technologies in I4.0, logistics 4.0, and digital SC to gain social, environmental, and economic benefits [74]. This study's results show that most publications analyzed have focused on I4.0, with digitalization technology prominent. Internal integration can be achieved by aligning all organizational processes, mainly supply and logistics. External integration can, on the other hand, be achieved by integrating all involved stakeholders, from suppliers to customers, along with the organization itself. Moreover, real-time decision-making and tracking are also possible with digitalization. The trend towards digitalization has clearly increased directly with time, as demonstrated in this study.

When analyzing across industry sectors of application for these technological trends, the present study has found that the agriculture and food sectors have gained the attention of scholars in logistics and SC studies [64,69]. Manufacturing, SC, and logistics were the prominent sectors of usage of these technologies across different market applications [62,70]. These results can change depending on the timeframe chosen, the study's framework design, inclusion and exclusion criteria, or by expanding the keyword formulas to other market applications. And these are avenues open for further research. However, the significant result is likely to remain true for a longer period, as it clearly demonstrates that an emergent trend in sustainability, SDG linking, and emerging information technologies is now being implemented in I4.0 and SC logistics studies and processes. Moreover, digitalization technology will continue to play a significant role across broader industrial sectors and contribute to sustainability from an I4.0 perspective.

The results showed that multiple technologies are indeed the preferred route, but also that AI and IoT dominated, while AR, VR, cloud computing, and robotics are still emerging. These trends showed the readiness level of each and allowed them to choose paths for implementing different technologies. Multiple technologies remain mainstream rather than choosing one in logistics. Moreover, multiple technologies are being used to improve logistics efficiency, forecasting, facilitation, and warehouse management at the lowest cost and with the greatest ease of use. In contrast, AR and VR are still emerging, as implementing these technologies requires higher costs, specialized training and skill sets, and other associated challenges.

The review confirms that digitalization and blockchain are the dominant technologies in Industry 4.0, with a strong focus on their ability to enhance operational efficiency, transparency, and decision-making. However, IoT and IIoT remain underexplored,

despite their potential to further support circular economy goals. This suggests a shift toward a multi-technology approach, where integrating various technologies rather than relying on a single one can lead to more sustainable outcomes.

Sectoral concentration in SC and logistics highlights the sector's strategic importance in the sustainability transition, especially during natural disasters such as pandemic-related disruptions. The sectors that have contributed most to sustainability are agriculture, food, manufacturing, logistics, and SC. In contrast, the fashion and automotive industries seem to need to increase their focus on sustainability and green practices in their operations to better align with and contribute to the SDGs. Additionally, other sectors, such as construction and pharmaceuticals, face both practical and research path-dependency challenges, which require further research in these expanded sectors to develop robust methodologies for mapping I4.0 adoption in logistics and further aligning with SDG outcomes.

The study shows that sectors such as agriculture and food have advanced significantly in adopting these technologies, while industries such as automotive and fashion lag behind in implementing sustainable logistics practices. This reflects broader industry-specific challenges and opportunities for further technological adoption, particularly in sectors where sustainability has yet to be a primary driver.

4.3. Alignment of Studies with UN SDGs (RQ 2)

The present study has explored whether and how scholars have aligned their studies with the SDGs. Our results show that this is indeed still very limited, but a shift has been observed since 2023 [74,81]. UN SDG midpoint reviews and EU funding frameworks, such as Horizon Europe and the Green Deal, required the community to explicitly align studies with the SDG framework, which may be the reason for the trend observed in this analysis. Additionally, it was found that there was a lack of a comprehensive SDG framework, rather than a focus on shaping the research design substantively.

A number of limited studies were conducted with explicit reference to SDGs [64,76]. The literature reviewed has focused on SDG 12, SDG 9, and SDG 13, which aim to develop links between I4.0 technologies and efficiency, with related goals. Moreover, these goals were applied with greater emphasis on environmental and economic concerns, while largely ignoring social goals. An operationalization of SDG frameworks into research designs and outcomes is required to ensure holistic support for sustainability, rather than just an efficiency gain.

The explicit integration of SDGs with literature faces challenges at the conceptual and methodological levels, as these studies treat the SDGs as a policy narrative rather than a research framework, leading to only superficial references. The operationalization of the SDGs at the organizational and supply chain levels remains challenging, particularly given the lack of standardized indicators.

While many studies address sustainability and the circular economy, few explicitly align their findings with the United Nations Sustainable Development Goals (SDGs). The lack of SDG alignment presents an opportunity for researchers and practitioners to ensure that digital supply chain innovations are designed not only for efficiency but also for long-term societal and environmental benefits.

4.4. Theories and Methodologies in the Intersection Among Technology, Sustainability, and Logistics (RQ 3)

From a theoretical perspective, analysis of scholars' theories and included publications has shown several different preferred frameworks. Social capital theory, used by authors mostly in Italy for sustainable SC, focuses on how social networks, relationships, and trust can enhance innovation, information flows, and economic opportunities by sharing resources and aligns with the SDGs. On the other hand, the resource-based view,

which focuses on the resources and capabilities needed to gain a competitive advantage, is also reported in the analyzed studies. The theory of planned behavior has also been found and has focused on attitudes and behavior toward adopting new technology for sustainability.

Authors from Italy have applied this theory to the CE. Mathematical graph theory has focused on mathematical techniques in SC and logistics for cleaner, circular SC, and was founded in Poland to support digital transformation. The knowledge-based view theory has focused on fostering innovation, learning, and better management of sustainable practices aligned with the SDGs, and it has been applied in Italy's logistics and SC sector.

Contributions to the SDGs from these sectors can be achieved using advanced information technologies, such as blockchain, to increase transparency and traceability, thereby increasing trust in SC and logistics operations [36]. Additionally, BDA and AI may help analyze the environmental impact of resource use across different scenarios. Moreover, IoT and CC can help organizations move towards digitalization and CE practices [67]. These technologies, when used together, will enable organizations to adopt green, sustainable, and circular practices, reduce emissions and waste, and recycle, moving towards green business models aligned with the SDGs.

In this systematic literature review, the most prominent methodology used by scholars was also analyzed. Similarly, this study follows a systematic literature review [50,79] Methodology, followed by case study and survey methods. The logic behind this methodological flow is that technologies have been changing rapidly, and advanced techniques and technologies have been introduced quickly. Therefore, the authors conduct a systematic literature review to identify the latest scientific outputs and technological trends, and then use the results to infer further and provide guidelines for other empirical or more marketing-related studies.

The review also identifies a methodological gap; most studies rely on systematic literature reviews, case studies, and surveys. Future research should consider more quantitative methodologies to better assess the causal relationships between digital transformation in supply chains and measurable sustainability outcomes.

Theoretical frameworks remain fragmented. The resource-based theory and the theory of planned behavior were indeed the most commonly used theories in this context. These theories emphasize gaining a competitive advantage and the intention to pursue specific, directed actions. Still, the multi-theory perspective remains underrepresented in the analyzed studies in this work. Moreover, institutional theory, resource dependence theory, stakeholder theory, and socio-technical aspects play an important role in sustainable logistics and SC, but these theories still require attention. From a methodological perspective, qualitative designs such as case studies and narrative reviews highlight the exploratory nature of this subject in academia, which may limit the generalizability of the data obtained in this study. While bibliometric studies demonstrate the growing maturity level of research. In contrast, quantitative methods such as surveys are increasingly used in these studies to explain the causal relationships among technology, logistics, and sustainability. Moreover, the quantitative mix method needs to be further employed in academic studies. Without a stronger theory of integration and methodological diversity, scholars may be unable to further extend, develop, and test the comprehensive framework in this area.

4.5. Trends and Areas for Further Investigation (RQ 4)

The network and word cloud analysis have confirmed that most of the analyzed studies are performance-oriented, focusing on efficiency, optimization, integration, innovation, materials, and economics. The social sustainability aspect remains suppressed under the economic and environmental aspects when considered. This creates a gap in the SC

and logistics literature, and today's consumers demand greater focus on social integration for the holistic implementation of the sustainability transition.

The cluster pattern derived from the included studies focused on environment, blockchain, digitalization, circular economy, climate change, and optimization. It indicates that technologies were mostly studied in isolation rather than in combination. There is a need for a synergetic approach to assess the combined effect on sustainability, including transportation- and logistics-oriented efforts, to generate more sustainable outcomes aligned with the SDGs.

A theory-driven framework and analysis required an emphasis on the contradiction and trade-offs between efficiency improvements and environmental externalities or rebound effects. This gap also explains why and how this happened and identifies the major causes of these effects in sustainable logistics.

The results point to the urgent need for more integrated, multi-theoretical frameworks in this area. Theories like the Resource-Based View (RBV) and the Theory of Planned Behavior are commonly used but fail to fully capture the complexities of technology adoption in the supply chain. Integrating the Technology Acceptance Model (TAM), Technology, Organizational, Environment (TOE) framework, and socio-technical theories could offer a more holistic perspective on the digital transformation of supply chains.

5. Conclusions

This study conducted a systematic literature review (2019–2024) to analyze the intersection of I4.0, SC, and sustainability, and their links to the SDGs. A total of 65 academic papers were found in this search to be relevant, and a final number of 39 full-text articles were included in this review and examined to answer the four research questions posed at the end of the introduction of this manuscript.

The present systematic literature review focused on logistics and SC technological transformation trends, analyzing the technologies used and their links to the SDGs framework. New technologies in the AI era are revolutionizing traditional SC and logistics operations, making them more efficient and transparent, enabling real-time responses, predicting future trends and patterns, and automating processes to add value to SC and logistics for the future. Similarly, adopting and implementing AR, VR, and ML will improve warehouse performance through demand forecasting, efficient use of warehouse space, and regulation of the inflow and outflow of raw and finished materials.

The findings showed that research on I4.0, SC, and sustainability has been increasing since 2019, particularly in the five analyzed countries of this study, driven most likely by the launch of the European Green Deal policy framework in 2029, sustainability goals, consumer demand, and the commitments countries have taken under the UN Decade of Action for SDGs.

This study has shown that this topic is highly relevant to the academic community, as most studies are published in high-impact Q1 journals. Even with a small sample of 5 countries, a reasonable number of studies in the last 5 years were found, and the trends indicate that this number is increasing. The results obtained have also demonstrated that Italy is the leading country amongst those studied in the study of emerging information technologies in manufacturing and SC logistics. Portugal and Slovenia are still developing their roadmaps and hold several opportunities to bolster the use of these technologies across the SC and logistics value chains. When considering technological trends, Industry 4.0 played a vital role in sustainable logistics 4.0. The data obtained revealed that multiple technologies (with AI and IoT being the most widely used) dominated, whereas AR and VR are still in the exploration stage. I4.0 seems to have gained momentum since 2023, when it spurred the adoption of multiple technologies to achieve sustainability across the manufacturing, agricultural, SC, and logistics sectors. The network analysis developed

within the scope of this study has highlighted I4.0 trends related to sustainability, CE, and environmental concerns in the sustainable SC, using both IoT and blockchain.

When analyzing these trends through the lens of the sustainability and SDGs frameworks, this study found that most scholars and analyses are now aligning with the SDGs. Our data indicated that SDG alignment is skewed toward environmental and efficiency-related aspects, while the social dimension is underrepresented. However, when comparing the most prominent theories, the resource-based theory, the theory of planned behavior, and knowledge-based theories were at the top, which may indicate that there is already a growing awareness of alignment between these studies and the needed sustainability framework and sustainable resource management along the CS and logistics value chains. Additionally, systematic literature reviews, bibliometrics, case studies, and survey methods have gained traction among academics. The results of this study highlighted the theoretical use; the resource-based view was prevailing but rarely integrated into the broader perspective. The quantitative mix-method approaches would be most suitable for explaining the causes of the observed relationships.

Finally, our word cloud analysis has shown that the literature primarily focuses on performance, SC, and technology, and aligns with the results obtained by the authors. This confirmed that most studies are performance-oriented and insufficient to explain social integration for critical reflection on systemic sustainability impacts.

5.1. Research Implications

The present study shows that the resource-based view (RBV) remains prominent, focusing primarily on competitive advantage. However, it has tended to overlook institutional and socio-technical aspects, which are essential for the effective implementation of Industry 4.0 in sustainable logistics. By highlighting this limitation, the study recommends the development of an integrated, multilevel framework that addresses not only efficiency and competitiveness but also broader sustainability concerns, particularly social sustainability, thereby contributing to theoretical advancement [110].

For managers and practitioners in sustainable logistics, the study also provides practical guidance. It demonstrates that multiple technologies, especially AI and IoT, are already mainstream in logistics, whereas AR and VR remain underutilized. The findings suggest that organizations adopting cross-technology strategies combining traceability, predictive analytics, and supply chain transparency can better balance efficiency with sustainability outcomes.

5.2. Limitations and Future Directions

The present study has three main limiting factors. First, this study was restricted to the period 2019–2024, and although it coincided with the launch of the Green Deal, it may be biased or limited by the COVID-19 pandemic's impact on these studies. In the future, this time frame can be increased, and comparisons on rate and coverage can be pursued. It will also provide insights into technological trends over time. Second, the geographical scope was somewhat limited; this study has selected only five countries: Italy, Portugal, Turkey, Poland, and Slovenia, as these countries are related to the scope of the funded project behind the study and sustainable logistics 4.0. However, future studies can expand on geographical coverage to further broaden this study's impact. Additionally, adding other EU countries (such as Ireland, Germany, and Finland) and Asian Countries (such as China, Pakistan, and India) may provide a more diverse and comparative cross-country perspective. Moreover, focusing on the selected five countries may create some regional bias. Additionally, it may create economic bias, as highly developed countries will adopt new technologies earlier than low-income countries, and in a smaller example like this, the bias effect can be greater.

Third, this study was also restricted to one database (Scopus) because it is the largest and aligns with the systematic literature review goals, especially those focused on I4.0, sustainability, and supply chain. However, other studies can be found in other databases such as Web of Science and IEEE, or multiple databases can be used in future studies. It will reduce the selection bias and increase inclusivity but substantially increase the study burden and time.

This systematic literature review can also be tested empirically in the future. This study focused on I4.0, but future studies can focus on Industry 5.0 (I5.0), an emerging concept. Moreover, this study has focused solely on the technological concept; in future studies, the human factor may also be analyzed, including training, technological capabilities, and management support. Finally, future studies can develop a comprehensive framework to integrate the I5.0 technological capabilities to create CE practices and achieve sustainable performance. Likewise, socioeconomic benefits can be achieved through logistics and digital transformation of the SC.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su18052318/s1>, PRISMA Checklist, and Table S1. Summary Characteristics of Included Studies.

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List of Abbreviations

The following abbreviations are used in this manuscript:

ABS	Association of Business Schools
AI	Artificial Intelligence
AR	Augmented Reality
BDA	Big Data Analytics
CC	Cloud Computing
CE	Circular Economy
CEO	Chief Executive Officer
CINEA	European Climate, Infrastructure and Environment Executive Agency
EU	European Union
GL	Green Logistics
GHG	Greenhouse Gas Emissions
IoT	Internet of Things
IIoT	Industrial Internet of Things
I4.0	Industry 4.0
I5.0	Industry 5.0
ML	Machine Learning
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SC	Supply Chain
SDGs	Sustainable Development Goals
SLR	Systematic Literature Review
UN	United Nations
VR	Virtual Reality

References

1. Delft, L.V. How Green Logistics can Transform Your Business. Available online: <https://www.dhl.com/discover/en-global/logistics-advice/sustainability-and-green-logistics/what-is-green-logistics> (accessed on 19 March 2025).
2. SAP. How to Close the Gap Between Sustainability and Profitability. Available online: <https://news.sap.com/africa/2022/07/how-to-close-the-gap-between-sustainability-and-profitability/> (accessed on 30 April 2025).
3. CINEA. Enabling Smart and Green Logistics. Available online: https://cinea.ec.europa.eu/publications/enabling-smart-and-green-logistics_en (accessed on 19 March 2025).
4. Belova, K. Digital Transformation in Supply Chain: Key Trends, Technologies, and Use Cases. 2022. Available online: <https://pixelplex.io/blog/what-is-digital-transformation-in-supply-chain/> (accessed on 19 March 2025).
5. Zhang, S.; Yu, Q.; Wan, S.; Cao, H.; Huang, Y. Digital supply chain: Literature review of seven related technologies. *Manuf. Rev.* **2024**, *11*, 8.
6. Gartner. Digital Supply Chain and Technology Transformation. Available online: <https://www.gartner.com/en/supply-chain/topics/supply-chain-digital-transformation> (accessed on 19 March 2025).
7. Yahya, H.; Anas, C.; Salaheddine, K.A. Exploring the Impact of Industry 4.0 Technologies on Logistics. In Proceedings of the 2024 World Conference on Complex Systems (WCCS), Casablanca, Morocco, 11–14 November 2024; pp. 1–5.
8. Hrouga, M.; Sbihi, A. Logistics 4.0 for supply chain performance: Perspectives from a retailing case study. *Bus. Process Manag. J.* **2023**, *29*, 1892–1919.
9. Garay-Rondero, C.L.; Martinez-Flores, J.L.; Smith, N.R.; Caballero Morales, S.O.; Aldrette-Malacara, A. Digital supply chain model in Industry 4.0. *J. Manuf. Technol. Manag.* **2020**, *31*, 887–933.
10. Kurniawan, T.A.; Othman, M.H.D.; Hwang, G.H.; Gikas, P. Unlocking digital technologies for waste recycling in Industry 4.0 era: A transformation towards a digitalization-based circular economy in Indonesia. *J. Clean. Prod.* **2022**, *357*, 131911.
11. Škare, M.; Gavurova, B.; Porada-Rochon, M. Digitalization and carbon footprint: Building a path to a sustainable economic growth. *Technol. Forecast. Soc. Change* **2024**, *199*, 123045.
12. Zhou, H.; Liu, J. Digitalization of the economy and resource efficiency for meeting the ESG goals. *Resour. Policy* **2023**, *86*, 104199.
13. Govindan, K. How digitalization transforms the traditional circular economy to a smart circular economy for achieving SDGs and net zero. *Transp. Res. Part E Logist. Transp. Rev.* **2023**, *177*, 103147.

14. Ren, S.; Hao, Y.; Wu, H. Digitalization and environment governance: Does internet development reduce environmental pollution? *J. Environ. Plan. Manag.* **2023**, *66*, 1533–1562.
15. Wang, W.; Xiao, D.; Wang, J.; Wu, H. The cost of pollution in the digital era: Impediments of air pollution on enterprise digital transformation. *Energy Econ.* **2024**, *134*, 107575.
16. Liu, Q.; Yang, L.; Yang, M. Digitalisation for water sustainability: Barriers to implementing circular economy in smart water management. *Sustainability* **2021**, *13*, 11868.
17. Agrawal, R.; Wankhede, V.A.; Kumar, A.; Upadhyay, A.; Garza-Reyes, J.A. Nexus of circular economy and sustainable business performance in the era of digitalization. *Int. J. Product. Perform. Manag.* **2022**, *71*, 748–774.
18. Martínez, J.M.G.; Puertas, R.; Martín, J.M.M.; Ribeiro-Soriano, D. Digitalization, innovation and environmental policies aimed at achieving sustainable production. *Sustain. Prod. Consum.* **2022**, *32*, 92–100.
19. Nobrega, J.H.C.; Rampasso, I.S.; Sanchez-Rodrigues, V.; Quelhas, O.L.G.; Leal Filho, W.; Serafim, M.P.; Anholon, R. Logistics 4.0 in brazil: Critical analysis and relationships with sdg 9 targets. *Sustainability* **2021**, *13*, 13012.
20. Makhmudov, S.; Khamdamov, S.-J. The Role of Green Logistics in Achieving SDG 13 (Climate Action) in Uzbekistan. *Best J. Innov. Sci. Res. Dev.* **2024**, *3*, 572–576.
21. Rosa, P.; Sassanelli, C.; Urbinati, A.; Chiaroni, D.; Terzi, S. Assessing relations between Circular Economy and Industry 4.0: A systematic literature review. *Int. J. Prod. Res.* **2020**, *58*, 1662–1687.
22. Krstić, M.; Agnusdei, G.P.; Miglietta, P.P.; Tadić, S. Logistics 4.0 toward circular economy in the agri-food sector. *Sustain. Futures* **2022**, *4*, 100097.
23. Dwivedi, A.; Paul, S.K. A framework for digital supply chains in the era of circular economy: Implications on environmental sustainability. *Bus. Strategy Environ.* **2022**, *31*, 1249–1274.
24. Shafique, M.N.; Adeel, U.; Rashid, A. The Synergy Between Industry 5.0 and Circular Economy for Sustainable Performance in the Chinese Manufacturing Industry. *Sustainability* **2024**, *16*, 9952.
25. Demestichas, K.; Daskalakis, E. Information and communication technology solutions for the circular economy. *Sustainability* **2020**, *12*, 7272.
26. Shafique, M.N.; Yeo, S.F.; Tan, C.L. Roles of top management support and compatibility in big data predictive analytics for supply chain collaboration and supply chain performance. *Technol. Forecast. Soc. Change* **2024**, *199*, 123074.
27. Yontar, E. Critical success factor analysis of blockchain technology in agri-food supply chain management: A circular economy perspective. *J. Environ. Manag.* **2023**, *330*, 117173.
28. Natrajan, N.S.; Sanjeev, R.; Jain, R.U. Sustainability in small and medium enterprises: A circular economy approach using cloud computing. *Bus. Strategy Dev.* **2024**, *7*, e370.
29. Fang, M.; Yu, Y.; Park, K.; Liu, F.; Xiao, S.S.; Shi, Y. Supply chain relationship dependencies and circular economy performance: The contingency role of digitalization capability. *J. Purch. Supply Manag.* **2024**, *30*, 100902.
30. Qian, C.; Gao, Y.; Chen, L. Green supply chain circular economy evaluation system based on industrial internet of things and blockchain technology under ESG concept. *Processes* **2023**, *11*, 1999.
31. Akbari, M.; Do, T.N.A. A systematic review of machine learning in logistics and supply chain management: Current trends and future directions. *Benchmarking Int. J.* **2021**, *28*, 2977–3005.
32. Bedi, P.; Das, S.; Goyal, S.; Rajawat, A.S.; Kautish, S. Revolutionizing sustainability: The role of robotics in supply chains. In *Computational Intelligence Techniques for Sustainable Supply Chain Management*; Elsevier: Amsterdam, The Netherlands, 2024; pp. 225–273.
33. Anawade, P.; Sharma, D. Robotics in supply chain management: Transforming logistics for industry 4.0. *AIP Conf. Proc.* **2025**, *3227*, 040002.
34. Alabdullay, A.; Alkhammas, A.; Abuzaid, F. The Impact of Using Virtual Reality in Business Sustainability. In *Business Development via AI and Digitalization: Volume 2*; Springer: Berlin/Heidelberg, Germany, 2024; pp. 231–239.
35. Shafique, M.N.; Rashid, A.; Bajwa, I.S.; Kazmi, R.; Khurshid, M.M.; Tahir, W.A. Effect of IoT capabilities and energy consumption behavior on green supply chain integration. *Appl. Sci.* **2018**, *8*, 2481.
36. Kayikci, Y.; Gozacan-Chase, N.; Rejeb, A.; Mathiyazhagan, K. Critical success factors for implementing blockchain-based circular supply chain. *Bus. Strategy Environ.* **2022**, *31*, 3595–3615.
37. Costa, F.; Frecassetti, S.; Rossini, M.; Portioli-Staudacher, A. Industry 4.0 digital technologies enhancing sustainability: Applications and barriers from the agricultural industry in an emerging economy. *J. Clean. Prod.* **2023**, *408*, 137208.
38. Oguntegbe, K.F.; Di Paola, N.; Vona, R. Blockchain technology, social capital and sustainable supply chain management. *Sinergie Ital. J. Manag.* **2021**, *39*, 163–188.

39. Cook, D.J.; Mulrow, C.D.; Haynes, R.B. Systematic reviews: Synthesis of best evidence for clinical decisions. *Ann. Intern. Med.* **1997**, *126*, 376–380.
40. Tranfield, D.; Denyer, D.; Smart, P. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *Br. J. Manag.* **2003**, *14*, 207–222.
41. Kitchenham, B. *Procedures for Performing Systematic Reviews*; Keele University: Keele, UK, 2004; Volume 33, pp. 1–26.
42. Higgins, J.P.; Green, S. Cochrane Handbook for Systematic Reviews of Interventions. Version 5.1.0. 2011. Available online: <https://www.cochrane.org/authors/handbooks-and-manuals/handbook/archive/v5.1.0> (accessed on 25 August 2025).
43. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* **2009**, 339.
44. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* **2021**, *372*, 71.
45. Zawawi, A.A.; Porter, N.; Ives, C.D. Influences on greenways usage for active transportation: A Systematic review. *Sustainability* **2023**, *15*, 10695.
46. Metrics, J. Scopus vs Web of Science: A Complete Comparison for Researchers. Available online: <https://www.journalmetrics.org/blog/scopus-vs-web-of-science> (accessed on 6 February 2026).
47. Mongeon, P.; Paul-Hus, A. The journal coverage of Web of Science and Scopus: A comparative analysis. *Scientometrics* **2016**, *106*, 213–228.
48. Burnham, J.F. Scopus database: A review. *Biomed. Digit. Libr.* **2006**, *3*, 1.
49. Pareek, P.; Gopalakrishnan, B. Mapping The Literature of Family Business Management (FBM): Bibliometric Analysis and Systematic Review. *MSA-Manag. Sci. J.* **2023**, *2*, 80–98.
50. Kamble, S.S.; Gunasekaran, A.; Gawankar, S.A. Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. *Process Saf. Environ. Prot.* **2018**, *117*, 408–425.
51. Beltrami, M.; Orzes, G.; Sarkis, J.; Sartor, M. Industry 4.0 and sustainability: Towards conceptualization and theory. *J. Clean. Prod.* **2021**, *312*, 127733.
52. Alshdaifat, S.M.; Aziz, N.H.A.; Alhasnawi, M.Y.; Alharasis, E.E.; Al Qadi, F.; Al Amosh, H. The role of digital technologies in corporate sustainability: A bibliometric review and future research agenda. *J. Risk Financ. Manag.* **2024**, *17*, 509.
53. Guandalini, I. Sustainability through digital transformation: A systematic literature review for research guidance. *J. Bus. Res.* **2022**, *148*, 456–471.
54. Commission, E. The European Green Deal: Striving to be the First Climate-Neutral Continent. Available online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (accessed on 23 August 2025).
55. Panwar, R.; Pinkse, J.; De Marchi, V. The future of global supply chains in a post-COVID-19 world. *Calif. Manag. Rev.* **2022**, *64*, 5–23.
56. World Bank Group. World Development Indicators: GDP Ranking (US\$). Available online: <https://datacatalog.worldbank.org/search/dataset/0038130/GDP-ranking> (accessed on 23 August 2025).
57. World Bank Group. Connecting to Compete 2023: The Logistics Performance Index and Its Indicators. Available online: https://lpi.worldbank.org/?utm_source=chatgpt.com (accessed on 23 August 2025).
58. European Commission. DESI Indicators: SMEs with at Least a Basic Level of Digital Intensity (DII v3, Available Years: 2021 and 2023), Small and Medium Enterprises (10–249 Persons Employed). Available online: https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/charts/desi-indicators?period=desi_2024&indicator=desi_sme_di3_gelo&breakdown=ent_sm_xfin&unit=pc_ent&country=AT,BE,BG,HR,CY,CZ,DK,EE,EU,FI,FR,DE,EL,HU,IE,IT,LV,LT,LU,MT,NL,PL,PT,RO,SK,SI,ES,SE (accessed on 23 August 2025).
59. Scimago. Scimago Journal & Country Rank. Available online: <https://www.scimagojr.com/> (accessed on 1 April 2025).
60. Bildirici, M.; Ersin, Ö.Ö. Nexus between Industry 4.0 and environmental sustainability: A Fourier panel bootstrap cointegration and causality analysis. *J. Clean. Prod.* **2023**, *386*, 135786.
61. Contini, G.; Peruzzini, M.; Bulgarelli, S.; Bosi, G. Developing key performance indicators for monitoring sustainability in the ceramic industry: The role of digitalization and industry 4.0 technologies. *J. Clean. Prod.* **2023**, *414*, 137664.
62. Ferreira, J.J.; Lopes, J.M.; Gomes, S.; Rammal, H.G. Industry 4.0 implementation: Environmental and social sustainability in manufacturing multinational enterprises. *J. Clean. Prod.* **2023**, *404*, 136841.
63. Hallioui, A.; Herrou, B.; Santos, R.S.; Katina, P.F.; Egbue, O. Systems-based approach to contemporary business management: An enabler of business sustainability in a context of industry 4.0, circular economy, competitiveness and diverse stakeholders. *J. Clean. Prod.* **2022**, *373*, 133819.

64. Kumar, S.; Raut, R.D.; Nayal, K.; Kraus, S.; Yadav, V.S.; Narkhede, B.E. To identify industry 4.0 and circular economy adoption barriers in the agriculture supply chain by using ISM-ANP. *J. Clean. Prod.* **2021**, *293*, 126023.
65. Senturk, S.; Senturk, F.; Karaca, H. Industry 4.0 technologies in agri-food sector and their integration in the global value chain: A review. *J. Clean. Prod.* **2023**, *408*, 137096.
66. Upadhyay, A.; Mukhuty, S.; Kumar, V.; Kazancoglu, Y. Blockchain technology and the circular economy: Implications for sustainability and social responsibility. *J. Clean. Prod.* **2021**, *293*, 126130.
67. Abbate, S.; Centobelli, P.; Cerchione, R. The digital and sustainable transition of the agri-food sector. *Technol. Forecast. Soc. Change* **2023**, *187*, 122222.
68. Bigerna, S.; Micheli, S.; Polinori, P. New generation acceptability towards durability and repairability of products: Circular economy in the era of the 4th industrial revolution. *Technol. Forecast. Soc. Change* **2021**, *165*, 120558.
69. Latino, M.E.; Menegoli, M.; Lazoi, M.; Corallo, A. Voluntary traceability in food supply chain: A framework leading its implementation in Agriculture 4.0. *Technol. Forecast. Soc. Change* **2022**, *178*, 121564.
70. Su, D.; Zhang, L.; Peng, H.; Saeidi, P.; Tirkolaee, E.B. Technical challenges of blockchain technology for sustainable manufacturing paradigm in Industry 4.0 era using a fuzzy decision support system. *Technol. Forecast. Soc. Change* **2023**, *188*, 122275.
71. Di Maria, E.; De Marchi, V.; Galeazzo, A. Industry 4.0 technologies and circular economy: The mediating role of supply chain integration. *Bus. Strategy Environ.* **2022**, *31*, 619–632.
72. Neri, A.; Negri, M.; Cagno, E.; Kumar, V.; Garza-Reyes, J.A. What digital-enabled dynamic capabilities support the circular economy? A multiple case study approach. *Bus. Strategy Environ.* **2023**, *32*, 5083–5101.
73. Aldrighetti, R.; Battini, D.; Das, A.; Simonetto, M. The performance impact of Industry 4.0 technologies on closed-loop supply chains: Insights from an Italy based survey. *Int. J. Prod. Res.* **2023**, *61*, 3004–3029.
74. Stefanini, R.; Vignali, G. The influence of Industry 4.0 enabling technologies on social, economic and environmental sustainability of the food sector. *Int. J. Prod. Res.* **2024**, *62*, 3800–3817.
75. Järvenpää, A.-M.; Salminen, V.; Kantola, J. Industrial Symbiosis, circular economy and industry 4.0—a case study in Finland. *Manag. Prod. Eng. Rev.* **2021**, *14*, 111–121.
76. Cvahte Ojsteršek, T.; Šinko, S.; Gajšek, B. Determining Learning Outcomes Relevant for Logistics Higher Education on Sustainability and Industry 4.0. *Teh. Glas.* **2023**, *17*, 447–454.
77. Ćwiklicki, M.; Wojnarowska, M. Circular economy and industry 4.0: One-way or two-way relationships? *Eng. Econ.* **2020**, *31*, 387–397.
78. Kazancoglu, Y.; Ozkan-Ozen, Y.D.; Sagnak, M.; Kazancoglu, I.; Dora, M. Framework for a sustainable supply chain to overcome risks in transition to a circular economy through Industry 4.0. *Prod. Plan. Control* **2023**, *34*, 902–917.
79. Matt, D.T.; Pedrini, G.; Bonfanti, A.; Orzes, G. Industrial digitalization. A systematic literature review and research agenda. *Eur. Manag. J.* **2023**, *41*, 47–78.
80. Teixeira, J.E.; Tavares-Lehmann, A.T. Industry 4.0: The future of manufacturing from the perspective of business and economics—a bibliometric literature review. *Compet. Rev. Int. Bus. J.* **2023**, *33*, 458–482.
81. Corallo, A.; Latino, M.E.; Menegoli, M.; Signore, F. Digital technologies for sustainable development of agri-food: Implementation guidelines toward Industry 5.0. *IEEE Trans. Eng. Manag.* **2024**, *71*, 10699–10715.
82. Stefanini, R.; Tancredi, G.P.C.; Vignali, G.; Monica, L. Industry 4.0 and intelligent predictive maintenance: A survey about the advantages and constraints in the Italian context. *J. Qual. Maint. Eng.* **2022**, *29*, 37–49.
83. Popkova, E.G.; Bogoviz, A.V.; Ekimova, K.V.; Sergi, B.S. Will Russia become a blueprint for emerging nations' high-tech reforms? Evidence from a 26-countries dataset. *Int. J. Innov. Stud.* **2023**, *7*, 294–306.
84. Lardo, A.; Mancini, D.; Paoloni, N.; Russo, G. The perspective of capability providers in creating a sustainable I4.0 environment. *Manag. Decis.* **2020**, *58*, 1759–1777.
85. Dieste, M.; Orzes, G.; Culot, G.; Sartor, M.; Nassimbeni, G. The “dark side” of Industry 4.0: How can technology be made more sustainable? *Int. J. Oper. Prod. Manag.* **2023**, *44*, 900–933.
86. Voza, D.; Szewieczek, A.; Grabara, D. Environmental sustainability in digitalized SMEs: Comparative study from Poland and Serbia. *Serbian J. Manag.* **2022**, *17*, 15–31.
87. Rasool, F.; Greco, M.; Morales-Alonso, G.; Carrasco-Gallego, R. What is next? The effect of reverse logistics adoption on digitalization and inter-organizational collaboration. *Int. J. Phys. Distrib. Logist. Manag.* **2023**, *53*, 563–588.
88. Kwilinski, A. The relationship between sustainable development and digital transformation: Bibliometric analysis. *Virtual Econ.* **2023**, *6*, 56–69.

89. Grybauskas, A.; Stefanini, A.; Ghobakhloo, M. Social sustainability in the age of digitalization: A systematic literature Review on the social implications of industry 4.0. *Technol. Soc.* **2022**, *70*, 101997.
90. Talafidaryani, M.; Jalali, S.M.J.; Moro, S. Digital transformation: Toward new research themes and collaborations yet to be explored. *Bus. Inf. Rev.* **2021**, *38*, 79–88.
91. Demir, S.; Gunduz, M.A.; Kayikci, Y.; Paksoy, T. Readiness and maturity of smart and sustainable supply chains: A model proposal. *Eng. Manag. J.* **2023**, *35*, 181–206.
92. Garrido, S.; Muniz, J., Jr.; Ribeiro, V.B. Operations management, sustainability & industry 5.0: A critical analysis and future agenda. *Clean. Logist. Supply Chain* **2024**, *10*, 100141.
93. Dias, V.M.R.; Jugend, D.; de Camargo Fiorini, P.; do Amaral Razzino, C.; Pinheiro, M.A.P. Possibilities for applying the circular economy in the aerospace industry: Practices, opportunities and challenges. *J. Air Transp. Manag.* **2022**, *102*, 102227.
94. Ding, S.; Ward, H.; Tukker, A. How Internet of Things can influence the sustainability performance of logistics industries—A Chinese case study. *Clean. Logist. Supply Chain* **2023**, *6*, 100094.
95. Khan, Y.; Su'ud, M.B.M.; Alam, M.M.; Ahmad, S.F.; Ahmad, A.Y.B.; Khan, N. Application of internet of things (IoT) in sustainable supply chain management. *Sustainability* **2022**, *15*, 694.
96. Mastos, T.D.; Nizamis, A.; Vafeiadis, T.; Alexopoulos, N.; Ntinis, C.; Gkortzis, D.; Papadopoulos, A.; Ioannidis, D.; Tzovaras, D. Industry 4.0 sustainable supply chains: An application of an IoT enabled scrap metal management solution. *J. Clean. Prod.* **2020**, *269*, 122377.
97. Nishant, R.; Kennedy, M.; Corbett, J. Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. *Int. J. Inf. Manag.* **2020**, *53*, 102104.
98. Kar, A.K.; Choudhary, S.K.; Singh, V.K. How can artificial intelligence impact sustainability: A systematic literature review. *J. Clean. Prod.* **2022**, *376*, 134120.
99. Post, P.o.G. AI and Robotics Push Ahead the Digital Transition of the Ports of Genoa. Available online: <https://www.portofgenoa.com/en/magazine/news/ai-and-robotics-push-ahead-the-digital-transition-of-the-ports-of-genoa.html> (accessed on 23 August 2025).
100. Trieste, I. Trieste Launches Digital Freight Corridor with New Port-Highway Agreement. Available online: <https://intrieste.com/2025/06/10/trieste-port-authority-and-highway-operator-sign-agreement-to-digitize-freight-traffic-flows/> (accessed on 23 August 2025).
101. Alavi-Borazjani, S.A.; Bengue, A.A.; Chkoniya, V.; Shafique, M.N. An Overview of Critical Success Factors for Digital Shipping Corridors: A Roadmap for Maritime Logistics Modernization. *Sustainability* **2025**, *17*, 5537.
102. Basulo-Ribeiro, J.; Ferreira, M.; Silva, J.P.; Correia, A.; Macedo, B.; Lopes, R.B.; Pimentel, C.; Teixeira, L. Digital transformation of maritime ports: A case of a Smart Pre-Gate in the Port of Sines. *Digit. Green Transit. Marit. Ports Trends Chall.* **2024**, 123–128. Available online: https://dSPACE.uevora.pt/rdpc/bitstream/10174/38558/1/DGTMP24_Book%20of%20Abstracts.pdf#page=123 (accessed on 23 August 2025).
103. Ślusarczyk, B. Industry 4.0: Are we ready? *Pol. J. Manag. Stud.* **2018**, *17*, 232–248.
104. Stanisławski, R.; Szymonik, A. Impact of selected intelligent systems in logistics on the creation of a sustainable market position of manufacturing companies in Poland in the context of Industry 4.0. *Sustainability* **2021**, *13*, 3996.
105. Brglez, K.; Čuček, M.; Kober, A.A.; Kovačič Lukman, R. Barriers and influencing factors in the implementation of circular economy in Slovenian road transport. *Clean Technol. Environ. Policy* **2024**, *27*, 3841–3861.
106. Groznik, A.; Kovacic, A.; Zoric, B.; Vivic, D. E-logistics: Informatization of Slovenian transport logistics cluster. In Proceedings of the 26th International Conference on Information Technology Interfaces, Cavtat, Croatia, 7–10 June 2004; pp. 101–106.
107. Ertürk, A.C. EU external governance in policy area under “embedded stalemate”: Navigating the dynamic networks of Turkish transport. *J. Contemp. Eur. Stud.* **2025**, *33*, 142–163.
108. Yılmaz, N.P. Türkiye's harmonization with the EU's maritime policies: An analysis in the framework of the EU country reports between 2018 and 2023. *Int. J. Soc. Inq.* **2024**, *17*, 449–466.
109. Baghir, B.G. Digital revolution: Technological advancements shaping Azerbaijan-Turkey logistics. *Entrep. Innov.* **2024**, *30*, 90–94.
110. Zhou, J.; Shafique, M.N.; Adeel, A.; Nawaz, S.; Kumar, P. What is theoretical contribution? A narrative review. *Sarhad J. Manag. Sci.* **2017**, *3*, 261–271.

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