Supply Chain Management in the Industry 5.0 Era: Strategic Implications

Abstract

Purpose
Industry 5.0 represents an evolution from Industry 4.0, yet ambiguities remain regarding the strategic frameworks necessary for effective supply chain management during this transition. This paper addresses a critical research gap by conducting a systematic review of the current literature to clarify these strategic relationships.

Design/Methodology/Approach
Employing a systematic analysis, we reviewed articles from diverse academic databases. This rigorous process utilised clearly defined inclusion criteria and thematic coding to examine strategic management approaches within the supply chain context of Industry 5.0 strategies. The analysis specifically focuses on strategies centred on human centricity, resilience, and sustainability.

Findings
Our review reveals that previous studies have largely isolated elements of strategic management, leaving a critical gap in understanding the integrated approach required for Supply Chain 5.0. The analysis identifies five key strategies—learning, organisational human capability, leapfrogging, disruption mitigation, and sustainable operations—that collectively form the basis for a robust transition framework.

Research Limitations/Implications
The findings are theoretically anchored in institutional theory, suggesting that a learning strategy must involve the deliberate selection of suppliers committed to sustainability. This insight invites further empirical investigation to validate the proposed framework across different industries.

Practical Implications
Two primary industrial applications emerge from our analysis: one in modernising healthcare systems and another in guiding the transition from Agriculture 4.0 to Agriculture 5.0. These applications demonstrate the practical relevance of the identified strategic components.

Originality/Value
By linking previously isolated strategic concepts, this review offers a novel perspective on the interplay between human centricity, resilience, and sustainability in supply chain management. The integrated framework presented not only bridges existing gaps in the literature but also sets the stage for future research aimed at achieving international standards of excellence in Industry 5.0.

Keywords : supply chain; industry 5.0; strategy; management; resilience; sustainability; human centricity

1. Introduction

The relationship between humans and machines is now essential to the emerging paradigms of manufacturing, particularly in light of the ongoing revolution (Pizoń and Gola, 2023). With the advent of Industry 4.0, the concept of Industry 5.0 has also emerged. This development addresses the limitations of Industry 4.0 concerning sustainability and worker wellbeing, which tend to prioritise production efficiency and flexibility through digitalisation and technology (Alves et al., 2023). Industry 5.0 marks a significant shift in manufacturing, emphasising the integration of skilled human technicians with advanced automation technologies. Unlike Industry 4.0, which primarily focuses on automation, Industry 5.0 seeks to combine human creativity and intellect with machines to enhance overall efficiency (Leng et al., 2022). Industry 5.0 can thus be seen as a progression and continuation of Industry 4.0 with its three main pillars. First, human-centricity focuses on combining advanced technologies with human creativity and well-being to create personalized, collaborative, and sustainable manufacturing processes (Butt & Ahmad, 2022). Second, resilience involves adaptive production systems that combine human expertise with advanced digital technologies to effectively anticipate and recover from disruptions, ensuring sustainable operations (Torres & Dominguez, 2022). Third, sustainability integrates circular economy principles, digital innovations, and eco-friendly practices to enhance resource efficiency, reduce waste, and promote socio-environmental balance (Garcia & Li, 2023).

The significance of Supply Chain Management in the context of Industry 5.0 research is crucial, as it acts as the key link between advanced technological integration and human-centric strategies. This integration ultimately ensures the achievement of resilience, sustainability, and operational excellence. This study emphasises that an effective supply chain is not merely logistical; it serves as a strategic enabler that harnesses emerging technologies to transform industry models, strengthen supplier relationships, and enhance adaptability. From a strategic perspective, Industry 4.0 has improved decision-making processes by providing real-time data analysis capabilities (Khan et al., 2023). Industry 5.0 has emerged as a vital aspect of contemporary industrial evolution (Leng et al., 2022). According to Alves et al. (2023), the shift from Industry 4.0 to Industry 5.0 can create a stable relationship between advanced technology and human welfare. This transition is also essential for developing long-term management strategies in the planning of manufacturing systems within enterprises (Pizoń and Gola, 2023). Similarly, Ghobakhloo et al. (2023) have highlighted the need for strategic realignment in financial business models as industries transition to Industry 5.0, moving away from traditional metrics such as investment returns and payback periods.

Recent research on Industry 5.0 in supply chain management has primarily focused on performance metrics and theoretical frameworks, often lacking practical strategic guidance. For instance, Nazarian and Khan (2024) examined aspects such as efficiency, visibility, and responsiveness, but did not provide a strategic implementation plan. Similarly, Ali et al. (2025) highlighted the fragmented nature of current research across various fields, emphasising the need for a unified strategic framework. In contrast, our paper specifically addresses this gap by presenting a strategic perspective. We outline actionable frameworks that help organisations adopt Industry 5.0 principles, tackle adoption challenges, and align their supply chain strategies with sustainability and human-centred objectives.

Previous research has explored various aspects of Industry 5.0. Coelho et al. (2023) investigated emerging concepts associated with Industry 5.0, while Golovianko et al. (2023) examined the transition from Industry 4.0 to Industry 5.0. Alves et al. (2023) focused on the human-centred elements of Industry 5.0. However, these studies only briefly addressed supply chain issues. Some scholars have started incorporating supply chain considerations into their analyses. For instance, Karmaker et al. (2023) investigated the sustainability challenges faced by supply chains in the post-pandemic landscape within the Industry 5.0 framework. Dwivedi et al. (2023) explored how Industry 5.0 interacts with circular supply chains, and Ahmad et al. (2023) assessed the role of artificial intelligence in building resilient supply chains in the aftermath of COVID-19. Despite these contributions, there is still limited research on the strategic implications of supply chains within the context of Industry 5.0.

Exploring this research gap is crucial because Industry 5.0 recognises the industrial sector's potential to achieve societal goals beyond merely creating jobs and driving economic growth. It aims to position the industry as a significant source of prosperity (Huang et al., 2022). A company's level of digital maturity provides a foundation for developing and implementing a digitalisation strategy (Hein-Pensel et al., 2023). To tackle contemporary industrial challenges, governments, businesses, and individuals must make strategic technological decisions (Pizoń and Gola, 2023).

This study is inspired by institutional theory, which posits that institutional innovation plays a crucial role in shaping supplier technologies, value creation, and the arrangement of manufacturing systems (Fogaça et al., 2022). Consequently, institutional theory offers valuable insights into the dynamics of Industry 4.0 (Gupta et al., 2020). Specifically, the development of new strategic knowledge is vital for promoting institutional growth in the context of knowledge-based innovation (Yin and Yu, 2022). Therefore, the aim of this paper is to examine the strategic effects arising from the transition to Supply Chain 5.0. To achieve this, our research centres on the following question:
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RQ: What are the key strategic approaches required for the transition to Supply Chain 5.0, and how do they relate to human centricity, resilience, and sustainability?

To address the question, we conducted a literature review using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach. Our analysis indicates that only 6% of the records we included are review papers, highlighting a significant gap in the existing knowledge regarding strategic implications in this field. This study presents a novel integrated framework that connects human centricity, resilience, and sustainability strategies in Supply Chain Management for Industry 5.0—an area that has not been thoroughly explored in current literature. By synthesising findings from our comprehensive review, we offer new insights that bridge the gaps between theoretical concepts and practical applications in strategic management. By establishing a unified approach, our research lays the foundation for future studies and practical implementations aimed at enhancing operational excellence in the evolving industrial landscape.

From a theoretical perspective, there is a notable lack of research on the strategic management aspects involved in this transition. This paper aims to address that gap by identifying five key strategies: enhancing learning, developing organisational capabilities, leapfrogging traditional practices, mitigating disruptions, and promoting sustainable operations. Unlike previous studies that primarily focus on technological innovations, this research underscores the relationship between Supply Chain 5.0 strategies and institutional theory. It illustrates how companies can institutionalise sustainable practices through strategic supplier selection and the development of relevant capabilities.

From a practical standpoint, the research outlines actionable strategies for businesses to manage the transition to Supply Chain 5.0, enabling decision-makers to focus on learning, workforce capability enhancement, and initiatives that build resilience. In contrast to broader discussions about Industry 5.0 implementation, this paper emphasises two particular industrial applications: Healthcare Systems, by tackling issues related to supply chain resilience and patient-centric logistics, and Agriculture 5.0, by facilitating the transition from Agriculture 4.0 to a more sustainable and technology-driven agricultural supply chain. The results provide companies with a pathway to incorporate sustainability into their supply chain strategies, in line with global sustainability objectives and emerging regulatory demands.

The rest of the paper is structured as follows. Section 2 outlines the literature review. Section 3 presents the results, while Section 4 discusses the findings. Theoretical and practical implications, as well as the future research agenda, are presented in Section 5. Finally, concluding remarks are included in Section 6.

2. Theoretical background

The institutional and resource-based theories have shed light on different dimensions of incorporating disruptive technologies into operations management. Specifically, the resource-based view emphasises the role of resource capabilities (Muduli *et al*., 2021) and advocates for firms to enhance their competitive edge by effectively obtaining and managing resources (Muduli *et al*., 2020; Barney, 1991; De Guimaraes *et al*., 2016; Sarkis *et al*., 2011). Conversely, the institutional theory has been linked to the wide-ranging effects of Industry 4.0 (Fogaça *et al*., 2022; Alamsjah and Yunus, 2022). In this part, we investigate the significant consequences of institutional theory on supply chain 4.0 and strategy development for supply chains, while also identifying gaps in understanding that could shed light on supply chain 5.0 strategies.

2.1 Institutional theory and supply chain 4.0

The advent of advanced technologies in the Industry 4.0 era has transformed the integration of supply chains (Jraisat *et al*., 2023a), introducing not just technological innovations but also embedding environmental and sustainable practices into the core of modern supply chain management (Jraisat *et al*., 2023b; Jæger *et al*., 2021). Institutional theory offers a lens to understand the uptake of supply chain 4.0, highlighting how inadequate institutional frameworks in developing nations can act as a barrier to full realisation (Alamsjah and Yunus, 2022). The conversation around Industry 4.0, influenced by institutional logic, is crucial in shaping the organisational identity associated with it (Fogaça *et al*., 2022). Consequently, institutional pressures for a digital and efficient supply chain ecosystem have furthered supply chain 4.0 practices (Gupta *et al*., 2020).

2.2 Institutional theory and supply chain strategies

The COVID-19 pandemic means businesses now have to adopt resilient and adaptable supply chain strategies to avoid disruption (Kazancoglu *et al*. 2023; Samadhiya *et al.* 2023). This shift results from global issues such as climate change, forcing companies to increasingly recognise the need to adopt more environmentally responsible supply chain practices (Sharma *et al*. 2022). Sony and Aithal (2020) discovered that institutional coercive, normative and mimetic pressures influence strategic technological adoption from the perspective of Industry 4.0 adoption, which together with the related technological diffusion (such as blockchain), may be under different institutional mechanisms depending on the country and the stage of diffusion (Wamba and Queiroz, 2022).

2.3 Industry 5.0 applications in supply chains

Recent studies on Industry 5.0 applications in supply chains show that combining human-centric technologies with advanced digital tools can greatly improve operational performance and sustainability. For example, Smith *et al*. (2021) found that collaborative robotics enhances efficiency, safety, and worker satisfaction. Garcia *et al*. (2022) revealed that digital twins allow real-time monitoring and dynamic adjustment of supply chain processes, reducing lead times and boosting responsiveness. Additionally, Müller *et al*. (2023) demonstrated that integrating sustainable technologies improves environmental outcomes and supply chain resilience. Nevertheless, challenges like high initial costs and workforce upskilling persist, as noted by Li and Wang (2020), highlighting the need for effective change management strategies to fully leverage Industry 5.0 innovations. Appendix A presents a comparative table of recent papers on this topic.

2.4 Industry 5.0 and balanced scorecard framework

The incorporation of Industry 5.0 technologies into supply chains presents new opportunities for enhancing organisational performance. While earlier studies frequently highlight innovation and coordination as key drivers of performance, this grouping can be better understood through the lens of performance measurement systems (PMS). Among the most pertinent tools for this purpose is the Balanced Scorecard (BSC), conceived by Kaplan and Norton, which expands performance assessment to encompass not just financial results but also operational, customer, and learning aspects. Technologies related to Industry 5.0—like collaborative robots (cobots), artificial intelligence, and digital twins—allow companies to track and enhance performance across all four perspectives of the BSC: Financial: Automation and data-informed decision-making help lower operational expenses and improve return on investment, while predictive analytics enhance management of working capital and cost-to-serve assessments. Customer: Tailoring services through AI and collaborative human-robot interactions boosts customer satisfaction and responsiveness. Digital platforms elevate service quality and transparency, thereby strengthening supply chain connections. Internal Business Processes: Intelligent factories and interconnected systems enhance process efficiency, minimise waste, and support just-in-time production approaches. The integration of real-time data facilitates quicker decision-making and ongoing process improvements. Learning and Growth: Technologies centred on human collaboration promote skills development and employee engagement. Platforms for knowledge sharing and digital training resources contribute to cultivating agile, technology-oriented teams, which are essential for maintaining innovation and long-term competitiveness.

2.5 Case studies

Murtaza et al. (2024) explored the transition from Industry 4.0 to Industry 5.0, focusing on predictive maintenance and condition monitoring. Their systematic review and case study highlighted the importance of combining human intelligence with advanced technologies to create a more collaborative and adaptable industrial environment. The study also identified significant challenges and offered suggestions for future research directions. In a similar vein, Shukla et al. (2025) examined the role of blockchain technology (BCT) in supporting circular economy (CE) practices within the framework of Industry 5.0, using a case study from the electronics industry. Their findings demonstrated that BCT greatly enhances CE by improving security, transparency, and traceability. Additionally, the successful implementation of BCT is supported by effective regulatory frameworks, strong collaboration among stakeholders, and access to enabling technologies.

2.6 Research gap

Industry understanding of how Industry 5.0 will transform institutional structures and supply chain processes is still developing. The impact of supply chain 4.0 strategies is largely understood within the framework of Industry 4.0. However, with the advent of Industry 5.0, which emphasises human-centric approaches, sustainability, and resilience, research into the institutional effects of integrating supply chain 5.0 strategies continues. Villar and colleagues (2023) have examined how Industry 5.0 could enhance supply chain optimisation and disruption management through comprehensive supply chain assessments, including the transition towards supply chain 5.0. Nonetheless, there is a noticeable gap in the literature concerning the strategic implications of adopting supply chain 5.0 strategies at the institutional level.

3. Research methodology

To perform literature analysis, we combine a systematic approach with a bibliometric approach. The aim was to identify leading papers and avoid the underrepresentation of irrelevant papers in the literature on supply chain 5.0 strategies. The methodological steps followed for the systematic and bibliometric analysis are presented in Figure 1.

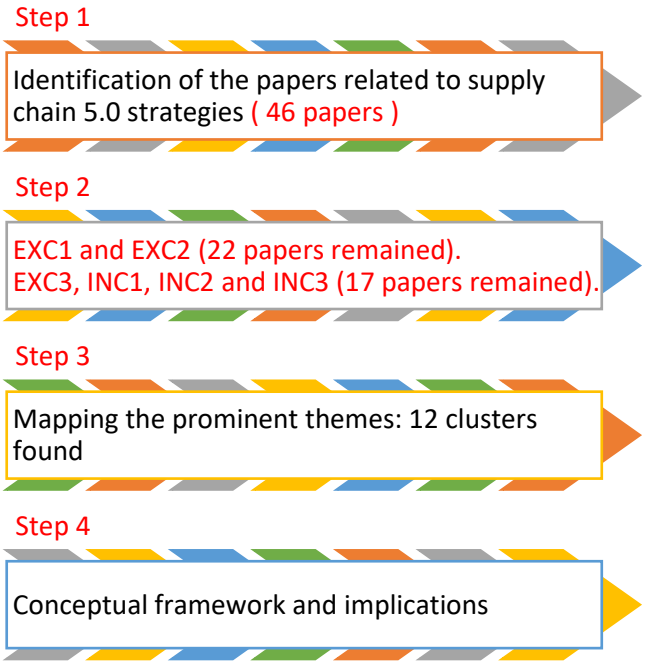

Figure 1. Methodological steps followed by a systematic and bibliometric analysis

3. 1 Step 1: Identification

The first step included the development of a search strategy. The systematic and bibliometric analysis was based on two databases, Scopus and Web of Science, which were chosen because of their selective indexing process. Scopus consists of various types of publications, including peer-reviewed academic journals, conference proceedings, book series, trade publications, and office patents. The platform supports bibliometric analysis, which includes being able to identify authors and their affiliations, analyse citations, perform publication analysis, and calculate the H-index (Bianchet *et al*., 2020). Whereas the Web of Science database provides access to abstracts across all fields of knowledge, and offers tools for citation and reference analysis, allowing for bibliometric analysis of approximately 12,000 journals.

Neither search had a specified start date so that the search engine could locate the earliest papers available in the literature. The search keywords were defined as: “Industry 5.0” AND “supply chain” AND “strategy”. The papers were extracted from all fields in the Web of Science, and articles, abstracts and keywords from Scopus. Appendix B presents figures on Web of Science papers, while Appendix C contains the topic word cloud.

3.2 Step 2: Screening and Eligibility

This step included a screening process for the papers. All conference papers and book chapters were excluded, instead opting for peer-reviewed journal articles to improve research quality. This choice was informed by the debate over the comparative merits of books versus journal articles. Hammarfelt *et al*. (2021) discussed how, despite the continued popularity of book chapters for disseminating research findings, their impact on academic recognition and career progression remains ambiguous. They suggested that embracing the standards of peer-reviewed journals might lead to forsaking book chapters in favour of more academically rewarding forms of publication. After this screening, any duplicate entries were eliminated.

The initial step involved an in-depth review and scrutiny of each paper's abstract, ensuring the inclusion of only those papers pertinent to our study.

3.3 Step 3: Inclusion and Exclusion

First, 46 records were retrieved from both databases. After examination of the extracted documents, the inclusion and exclusion criteria were defined (Table 1). This evaluation allowed us to determine which documents met the criteria. By considering EXC1 and EXC2, 24 papers were excluded, and 22 remained. Finally, by considering EXC3, INC1, INC2 and INC3, a total of 17 articles were selected with which to conduct the literature review. The selected studies might exhibit potential biases that influence the conclusions. In particular, depending on case-based research and self-reported information can lead to selection bias by disproportionately highlighting successful implementations.

Table 1: Inclusion and exclusion criteria

	Criteria	Description
Exclusion (EXC)	EXC1	Book chapters
	EXC2	Conferences
	EXC3	Irrelevant abstract
Inclusion (INC)	INC1	English text only
	INC2	Full papers found only
	INC3	Papers regarding general disruptive technologies and Industry 4.0

A preliminary analysis was performed to classify the selected papers in terms of research type, years, geographic area under investigation and journals. These categorisations reveal the patterns of the increasing knowledge of supply chain 5.0 strategies. Figure 2 shows that 41% of the records under investigation were empirical. As this is an emerging topic, it is predicted that this rate will increase in the next few years.

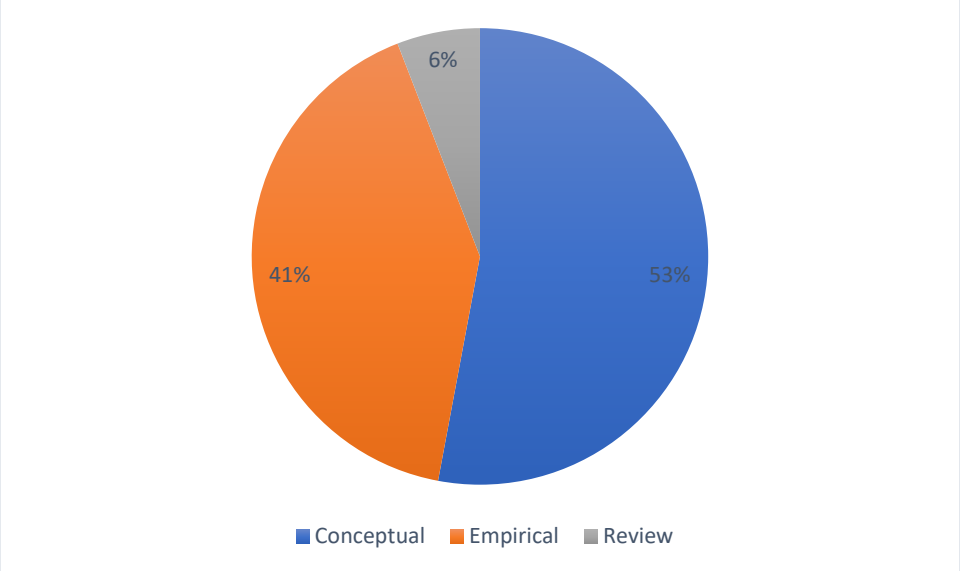

Figure 2. Types of papers

Table 2 shows the geographical location of the papers. This was not determined based on the affiliations of the authors; these statistics were derived from the full paper investigation. Most papers did not have a specific regional scope. Nevertheless, four countries are eminent, namely: Iran, Turkey, Malaysia and China.

Table 2. Distribution per country

Regional scope	Rate
General	70.58%
Iran	5.88%
Turkey	5.88%
Malaysia	5.88%
China	5.88%
Europe	5.88%

Table 3 shows the publication journals. The publication outlets consisted of a wide range of supply chain and operations journals. Research began in 2019, when Rahman *et al*. (2019) and Zambon *et al*. (2019) published the first two papers, including some insights into Industry 5.0 and supply chain strategies. As of 2023, publications in this specific niche remain limited.

Table 3: Distribution per journal

Journal	Number of publications
Anais da Academia Brasileira de Ciencias	1
Annals of Operations Research	1
Energies	1
Expert Systems with Applications	1
Industrial Management and Data Systems	1
International Journal of Production Research	1
International Journal of Supply Chain Management	1
Journal of Organizational Behavior Research	1
Logistics	1
Machines	1
Processes	2
Production and Operations Management	1
Sensors	1
Sustainable Production and Consumption	1
Technological Forecasting and Social Change	1
Technology in society	1

VOSviewer was used to conduct a bibliometric keywords analysis, which allowed us to identify the leading research streams. The concept of keyword occurrence refers to the frequency of keywords used among all the papers under investigation and, therefore, implies a strong connection between them.

For each database, a separate VOSviewer analysis was performed. All keywords were considered, including authors and indexed keywords. For Scopus, the minimum number of keyword occurrences was set as two. Twelve was the maximum number of keywords to be

selected. Table 4 shows the occurrences and total link strength for each keyword. We defined the clusters that represented the hidden themes (Figure 3), namely: sustainability, resilience, performance, human centricity and digitalisation.

VOSviewer uses co-occurrence coupling techniques to identify clusters by grouping related publications or keywords. It employs a mapping and clustering algorithm that calculates similarity scores, positioning closely related items nearby to form distinct clusters. The software partitions the network into these clusters by maximising internal relationships within groups and minimising connections between different ones. The result shows twelve cohesive research themes or areas based on VOSviewer's optimisation algorithm. These clusters emphasise application areas including real-time tracking and predictive analytics for improved supply chain visibility, cyber-physical integration for greater production agility, and sustainability practices like remanufacturing and reverse logistics.

Table 4. Scopus occurrences and total link strength

Keyword	Occurrences	Total link strength
Industry 5.0	10	22
Supply chains	5	17
Industry 4.0	6	16
Sustainable development	3	12
Human centricities	2	10
Digitalisation	2	9
Resilience	2	9
Performance	2	6
Supply chain 5.0	2	6
Supply chain	3	5
Sustainability	2	5
Systematic literature review	2	3

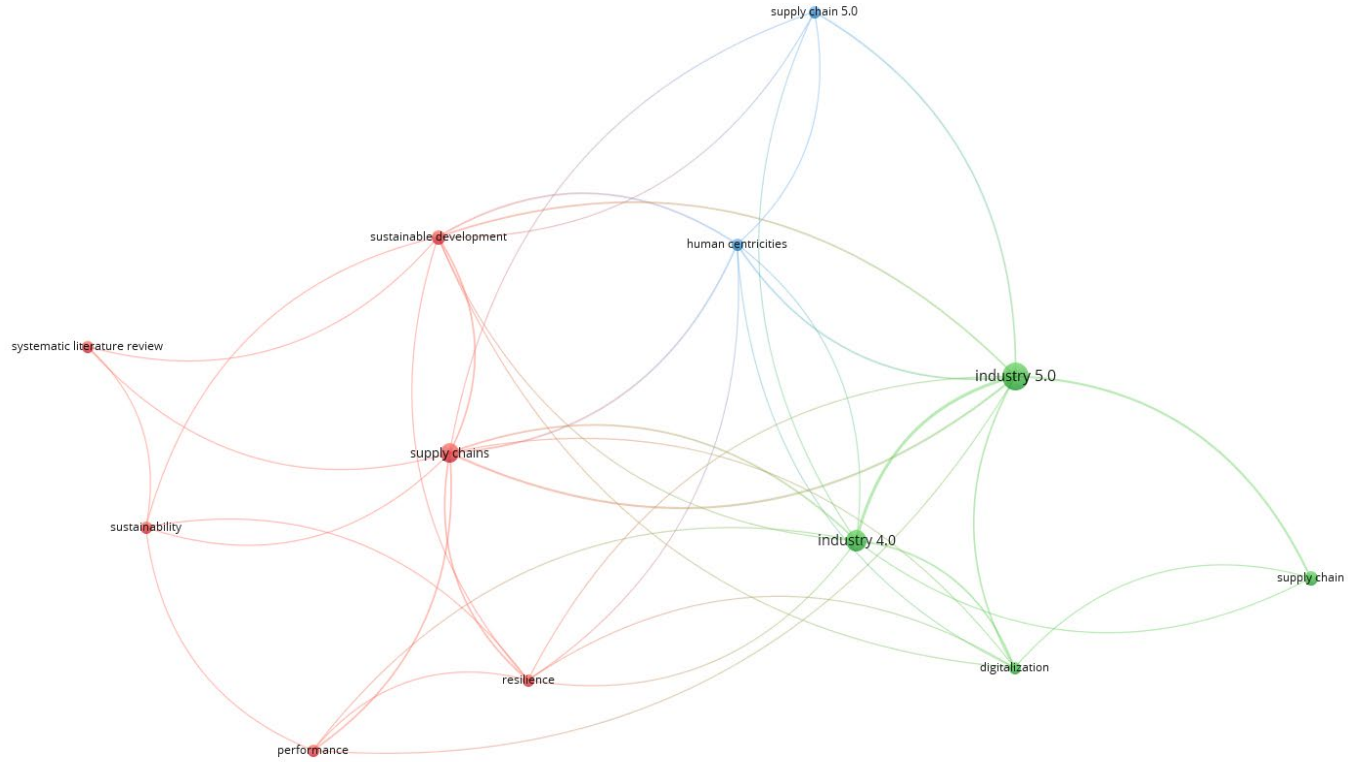

Figure 3. Scopus occurrence keywords

For the Web of Science database, three was set as the minimum number of keyword occurrences. Twelve was the maximum number of keywords to be selected. Table 5 shows the occurrences and total link strength for each keyword. Accordingly, we define the clusters that represent the hidden themes following the occurrence keywords graph (Figure 4), namely: model, management, performance, big data, impact, risk, internet and design.

Table 5. Web of Science occurrence strengths

Keyword	Occurrences	Total link strength
Industry 5	8	29
Industry 4	5	19
Model	5	19
Management	4	18
Performance	3	14
Big data	3	11
Supply chain	4	11
Impact	4	9
Risk	3	9
Internet	3	7
Design	3	4

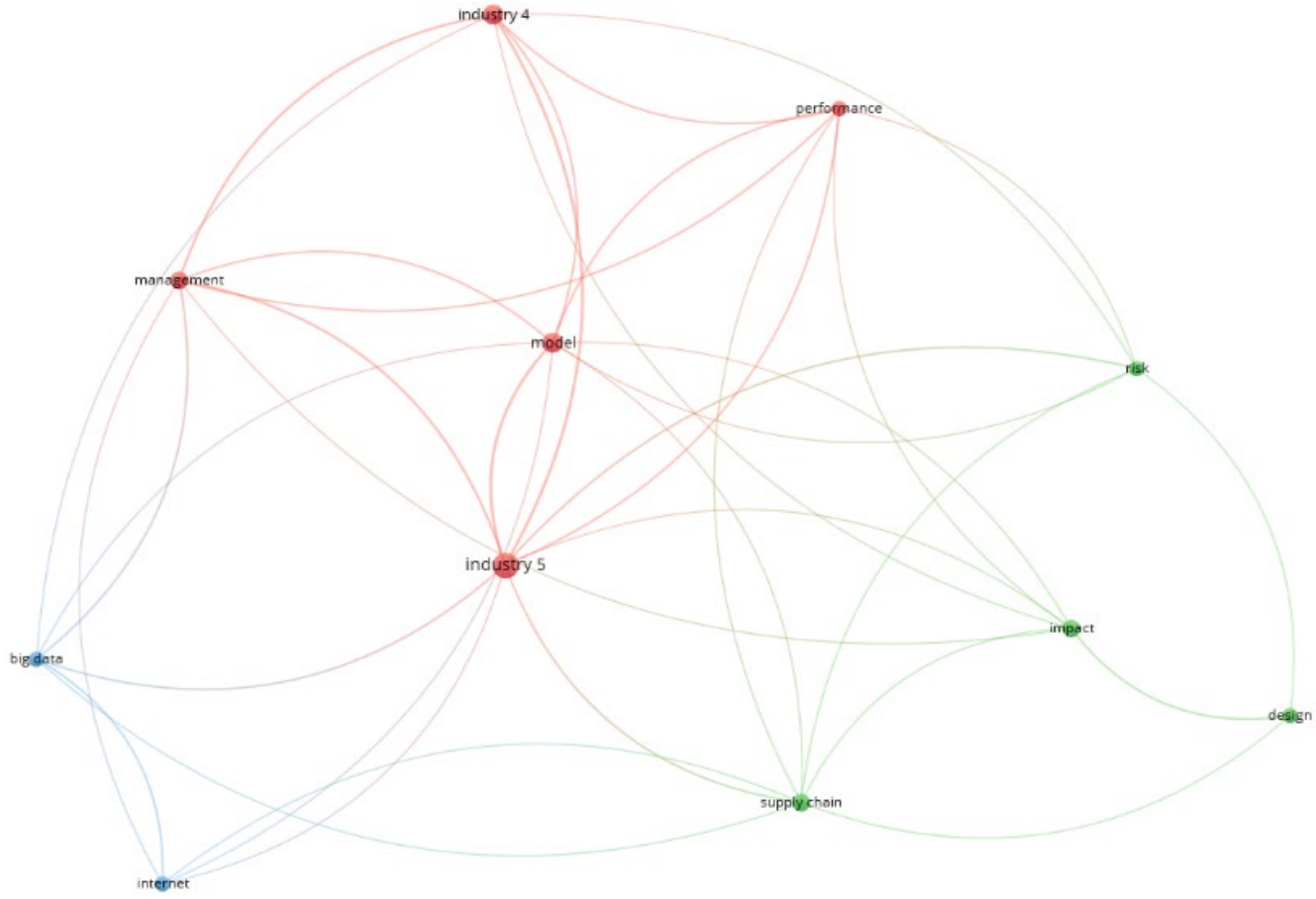

Figure 4. Web of Science occurrence keywords

4. Cluster Analysis

Table 6 summarises the papers for each of the clusters between the Scopus and Web of Science databases. The corresponding papers were identified for each cluster based on the membership of the cluster's name in the keywords of the paper, i.e. author, indexed and keywords plus. Twelve clusters are identified. Performance was the common cluster between both databases.

Table 6. Cluster identified

Cluster	Paper	Scopus clusters	Web of Science clusters
Sustainable development-sustainability	Grzybowska and Stachowiak (2022).	x	
	Ghobakhloo *et al*. (2022)		
	Maric *et al*. (2023)		
	Nayeri *et al*. (2023)		
Resilience	Saisridhar *et al* (2023)	x	
	Grzybowska and Stachowiak (2022).		
	Ghobakhloo *et al*. (2022)		
	Leng *et al*.(2022)		
Performance	Grzybowska and Stachowiak (2022).	x	x
	Yuan *et al*. (2022)		
	Brauner and Ziefle (2022)		
	Modgil *et al*. (2023)		
Human centricity	Modgil *et al*. (2023)	x	
	Ghobakhloo *et al* (2022)		
	Alojaiman (2023).		
	Nayeri *et al.* (2023)		
Digitalisation	Rahman *et al*. (2019)	x	
	Ghobakhloo *et al*. (2022)		
Model	Modgil *et al*. (2023)		x
	Frederico (2021)		
	Jandl *et al.* (2021)		
	Yuan *et al.* (2022)		
	Nayeri *et al*. (2023)		
Management	Kumar and Mallipeddi (2022).		x
	Maric *et al.* (2023)		
	Saisridhar *et al*. (2023)		
	Brauner and Ziefle (2022)		
	Modgil *et al.* (2023)		
	Frederico (2021)		
	Leng *et al.* (2022)		
	Yuan *et al*. (2022)		
Big data	Frederico (2021)		x
	Zambon *et al*. (2019)		
	Leng *et al*. (2022)		
Impact	Saisridhar *et al*. (2023)		x
	Maric *et al.* (2023)		
	Yuan *et al.* (2022)		
	Alvarez-Aros and Bernal-Torres (2021).		

Risk	Saisridhar *et al*. (2023)		x
	Modgil *et al*. (2023)		
	Grzybowska and Stachowiak (2022).		
	Kumar and Mallipeddi (2022).		
Internet	Leng *et al.* (2022)		x
	Jandl *et al.* (2021)		
	Zambon *et al*. (2019)		
Design	Jandl *et al.* (2021)		x
	Grzybowska and Stachowiak (2022).		
	Maric *et al*. (2023)		
	Alvarez-Aros and Bernal-Torres (2021).		
	Nayeri *et al*. (2023)		

During the recent COVID-19 pandemic, significant impacts on various dimensions of supply chain and operations management have been observed (Fares and Lloret, 2023; Fares *et al*., 2023c), highlighting the importance of integrating resilience and sustainability into these systems (Grzybowska and Stachowiak, 2022). In this context, Industry 5.0 is particularly notable for its potential to enhance sustainability, resilience, and human-centric approaches (Alojaiman, 2023; Nayeri *et al*., 2023). This paper discusses findings concerning existing scholarly discourse across various thematic clusters.

Cluster 1: Sustainable Development

Companies can utilise advanced technologies and tools to tackle contemporary challenges. For instance, forecasting methods can significantly enhance sustainability and resilience within supply chains (Grzybowska and Stachowiak, 2022). Likewise, Ghobakhloo et al. (2022) presented an interpretive framework that highlights Industry 5.0's potential to promote sustainable development through resilience, environmental stewardship, and a human-centric approach. Industry 5.0 encourages organisations to adopt sustainable practices, thereby supporting long-term sustainability (Ghobakhloo et al., 2022) and enhancing resilience through better system integration and interoperability. Maric et al. (2023) emphasised the potential of 3D printing technology to help meet sustainable development goals by offering economically viable and innovative solutions for communities in need. Additionally, Nayeri et al. (2023) identified responsiveness and sustainability as critical attributes that enhance the industrial capabilities of Industry 5.0.

Cluster 2: Resilience

Saisridhar *et al.* (2022) emphasised the significance of the triple R—responsiveness, resilience, and robustness—in reducing the risk of disruptions. Moreover, enhancing supply chain capabilities to predict disruptions is crucial for fostering supply chain resilience (Grzybowska and Stachowiak, 2022). Unlike Industry 4.0, Industry 5.0 is recognised for its potential to achieve superior levels of resilience (Leng *et al*., 2022). They emphasised that precision and promptness in detecting flaws play critical roles in enhancing system resilience as we transition

towards Industry 5.0. The researchers also highlighted the metaverse as an area worth exploring within the realm of blockchain development to boost system resilience.

Cluster 3: Performance

The importance of risk mitigation strategies in improving the financial outcomes of supply chains cannot be overstated (Grzybowska and Stachowiak, 2022). In line with this perspective, Yuan et al. (2022) examined how innovation within supply chains affects their performance metrics, suggesting that these innovations play a crucial role in enhancing performance. Additionally, variability within the supply chain is recognised as a factor that detracts from optimal performance (Brauner and Ziefle, 2022). To achieve superior organisational performance, it is essential for a digital supply chain to have continuous coordination, effective communication, and integrated functions (Modgil et al., 2023).

Cluster 4: Human-Centricity

In the Industry 5.0 framework, Modgil *et al*. (2023) emphasised human capacities for supply chain management. Supply chain experts should adopt solutions that combine human capability and technological inputs (Modgil *et al.,* 2023). By including sustainability in innovation processes, elements of Industry 5.0 can be used to construct smart workplaces and increase human capacity (Ghobakhloo *et al*., 2022). Human-centricity is the position of humans in communities and industries and the importance they place on their demands (Nayeri *et al.*, 2023). Nayeri *et al.* (2023) emphasised the critical significance of human factors in the sustainability of Industry 5.0.

Clusters 5 and 6: Digitalisation and Modelling

As a result of its ability to digitalise industrial value networks, Industry 5.0 is a technical phenomenon (Ghobakhloo *et al.*, 2022). From a modelling standpoint, Modgil *et al*. (2023) suggested two models, AHP and DEMATEL, for identifying and assessing the talents and sub-skills needed by supply chain professionals within Industry 5.0 settings. Yuan *et al*. (2022) utilised a cross-sectional regression model to examine the impact of supply chain innovation in the setting of Industry 4.0 and Industry 5.0. Nayeri *et al*. (2023) proposed a model based on the FVIKOR and the stochastic BWM to examine the responsive supply chain pillars of Industry 5.0.

Cluster 7: Management

Kumar and Mallipeddi (2022) highlighted significant trends and future research areas regarding the role of cybersecurity across various domains of operations and supply chain management. Similarly, Maric *et al*. (2023) offered insights on managing innovation in 3D printing technologies within operations and supply chain sectors. Moreover, Saisridhar *et al.* (2022) pointed out the urgent need for innovative supply chain management strategies to tackle challenges like the concept of supply chain as a service. Brauner and Ziefle (2022) introduced a supply chain management simulation game to practice quality management techniques. Additionally, Modgil *et al*. (2023) focused on the importance of strategic talent acquisition and management in light of Industry 5.0, whereas Frederico (2021) discussed various Industry 5.0 frameworks relevant to supply chain management. In an era characterised by rapid data production, managing access to and the security of data becomes crucial (Leng *et al.*, 2022).

Innovations in the supply chain are essential for meeting consumer needs and enhancing risk management strategies (Yuan *et al.*, 2022).

Cluster 8: Big Data

Big data is an important element of Industry 5.0 (Frederico, 2020). However, Industry 4.0 has been stated to be responsible for the introduction of big data (Zambon *et al.*, 2019). In addition, Industry 4.0 is seen as crucial for Industry 5.0. Leng *et al*. (2022) noted the importance of big data analytics in digital transformation in the context of IIoT. In addition, the study remarks that there are several associated topics, including dealing with complexity, security management and heterogeneity.

Cluster 9: Impact

Saisridhar and colleagues (2022) emphasised the urgent need for simulations that can incorporate socio-ecological factors to address the societal challenges associated with Industry 5.0. Maric and others (2023) examined how innovations in 3D printing technology impact business management strategies. For investors, the shift from Industry 4.0 to Industry 5.0 is crucial for decision-making. Yuan and his team (2022) explored how announcements regarding supply chain innovations influence investor perceptions and market value within the contexts of Industry 4.0 and 5.0. They found that such announcements often elicit positive reactions in the stock market, which helps executives improve their firms' market valuations. Additionally, Alvarez-Aros and Bernal-Torres (2021) studied the technological competitiveness and advancements of Industries 4.0 and 5.0, aiming to identify key attributes that differentiate developed economies from developing ones.

Cluster 10: Risk

Using computer simulation, Saisridhar *et al*. (2022) performed an assessment of the supply chain triple-R (responsiveness, resilience and robustness) for risk mitigation. Specific abilities help professionals in Industry 5.0 to handle such difficulties. To tackle supply chain issues, it is essential to have improved technical skills such as supplier collaboration and risk analytics (Modgil *et al*., 2023). In terms of Industry 5.0, where emerging technologies are more widely used, enterprises now face new cybersecurity challenges. However, as Kumar and Mallipeddi (2022) state, cybersecurity challenges can be handled via technology management. Grzybowska and Stachowiak (2022) highlight the financial performance of businesses as another part of risk mitigation.

Cluster 11: Internet

Leng *et al*. (2022) assessed the literature on safe blockchain middleware for decentralised Industrial Internet of Things (IIoT) towards Industry 5.0, where privacy and security remain major concerns. Jandl *et al*. (2022) discussed several ways to include privacy aspects in tracking and tracing systems. Nevertheless, Zambon *et al.* (2019) stated that the Internet functions as a storage and communication infrastructure that supports the effective coordination and control of corporate activities.

Cluster 12: Design

Jandl *et al.* (2022) proposed Privacy by Design (PbD) for helping to release the full potential of asset monitoring technology in the industry. Thus, Maric *et al*. (2023) demonstrated the role

of 3D printing in the design of modern production lines during the transition from Industry 4.0 to 5.0. Nayeri *et al.'s* (2023) findings can be used to create a supply chain network based on Industry 5.0 pillars.

5. Results and Discussion

Figure 5 was developed from the cluster analysis. The framework identifies five key strategies that are related to a transition to supply chain 5.0. These include a Learning Strategy, Organisational Human Capability Strategy, Leapfrogging and Industry Strategy, Disruption Mitigation Strategy and Sustainable Operations Strategy. A diagnostic checklist that supply chain managers can use to evaluate their organisation's readiness or progress in each area is available in Appendix D.

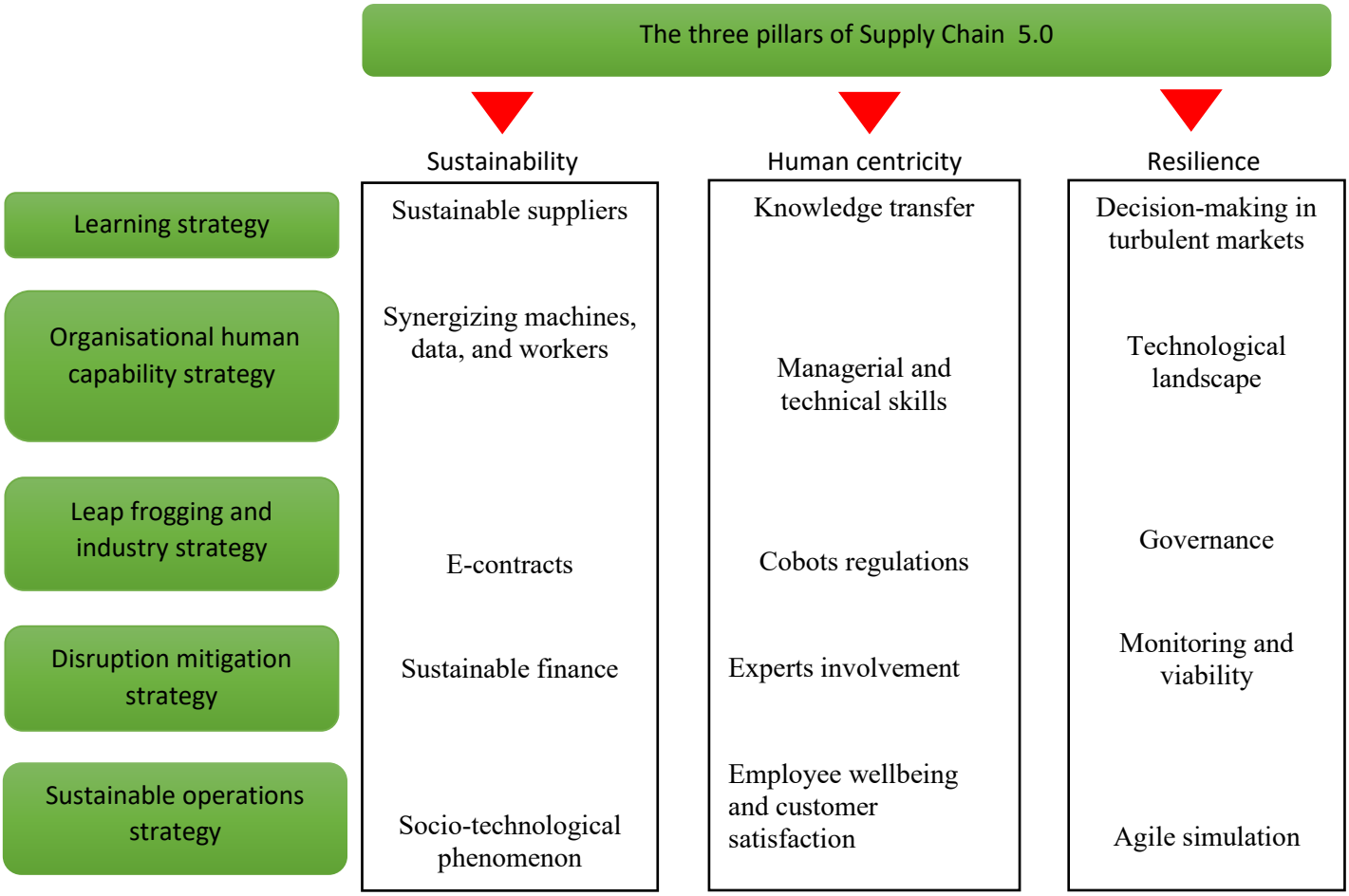

Figure 5. A framework of the strategic implications of SC 5.0

5.1 Learning Strategy

Serious games can serve as a powerful learning tool (Brauner and Ziefle, 2022) by promoting engagement with eco-friendly suppliers and evaluating sustainable production systems. Through interactive experiences, these games train staff to make sustainability-focused decisions under cost-related pressures while also facilitating effective knowledge transfer. In turn, participants gain a deeper awareness of supply chain complexities—including the bullwhip effect—and develop greater resilience, faster information processing, and enhanced

decision-making skills. Furthermore, supply chain management simulations help maintain stability amidst market fluctuations by refining decision-making processes. By altering various variables within these simulations, it is possible to assess how changes in demand or supplier quality affect participants' economic outcomes.

5.2 Organisational Human Capability Development Strategy

Building on the emphasis on learning, Industry 5.0 highlights the critical interplay among technology, societal needs, real-time data, and seamless supply chain operations in achieving sustainability. This approach goes beyond standard automation and technical advancement by integrating human creativity with intelligent systems and machinery. As Modgil *et al*. (2023) suggest, developing the right mix of managerial, operational, and leading-edge technical skills among supply chain professionals is paramount. By prioritising these competencies, organisations can attract, nurture, and retain talent capable of driving strategic objectives and safeguarding competitiveness. Given the limited availability of such expertise, organisations need to adapt continuously to the changing technological environment to maintain interoperability and ensure real-time access to information.

5.3 Leap-Frogging and Industry Strategy

The concept of a leapfrogging strategy has become essential for the ongoing success of logistics firms operating under the Industry 5.0 paradigm, highlighting the need for targeted human capabilities. According to Rahman et al. (2019), implementing electronic contracts can enhance transparency in customer agreements and negotiations by utilising data, which in turn reduces dependence on physical assets. This strategy also shows potential for strengthening collaborations with manufacturers in the realm of mobile marketing. Additionally, the emergence of Industry 5.0 brings attention to governance and ethical issues (Frederico, 2021), particularly regarding the regulation of human-robot interactions. Addressing these issues necessitates a comprehensive examination of ethical, psychological, legal, social, and educational factors.

5.4 Disruption and Mitigation Strategy

While Industry 5.0 supports growth and innovation, several scholars caution that it may pose environmental risks. In response, Grzybowska and Stachowiak (2022) underscore the importance of mitigation efforts—such as sustainable finance policies and the integration of energy and transportation initiatives—to spur the development of new sustainable enterprises. Meanwhile, the ongoing digital transformation triggers global shifts that are changing the scale, duration, and frequency of supply chain disruptions. As a result, resilience strategies must centre on the continuous monitoring and evaluation of these disruptions' impacts. To ensure a genuinely human-centric approach, specialists must be involved in designing mitigation measures that align with ethical and societal considerations.

5.5 Sustainable Operations

Finally, Industry 5.0 significantly advances eco-friendly and socially responsible manufacturing and operational practices (Kumar and Mallipeddi, 2022), signalling a socio-technological transformation that values both innovation and stakeholder engagement (Ghobakhloo *et al*., 2022). From this human-centred standpoint, employees and consumers alike benefit from technologies expected to bolster social welfare within intelligent social factories (Ghobakhloo *et al*., 2022). The concept of mass customisation likewise facilitates flexible production systems that can rapidly adapt to changing consumer demands. Furthermore, incorporating 3D printing into the Industry 5.0 landscape represents a promising avenue for future research (Marić *et al*., 2023). By leveraging dynamic simulations and

extensive data analytics to create digital twins of supply chain operations, organisations can pinpoint bottlenecks, vulnerabilities, and potential disruptions, thereby enhancing responsiveness and resilience (Ghobakhloo *et al*., 2022).

5.6 Unexplored areas of investigation

However, there are still some unexplored areas for investigation as described below :

- Human-Centric and Automation Integration: Industry 5.0 emphasises the collaboration between humans and intelligent machines. However, it remains unclear how to optimally design workflows that leverage both human creativity and machine precision without causing friction.

- Sustainability and Circular Economy Frameworks: There is a lack of clear, actionable frameworks that incorporate circular economy principles directly into Industry 5.0 strategies. These frameworks are essential for ensuring resource efficiency, waste reduction, and environmental sustainability throughout production cycles.

- Cybersecurity in Human-Robot Collaboration: With the increased connectivity and data exchange between humans and robots, specific cybersecurity risks emerge that traditional security measures do not fully address. This is particularly crucial for protecting privacy and maintaining system integrity in collaborative environments.

- Workforce Upskilling and Reskilling Models: Effective strategies for training and preparing employees to work alongside advanced Industry 5.0 technologies are lacking. Existing training models often do not account for the rapid pace of technological change or the diverse skill levels of the workforce.

- Socio-Technical and Ethical Implications: The impact of Industry 5.0 on organisational culture, employee well-being, ethical considerations, and societal acceptance has not been thoroughly studied. This lack of research makes it more challenging to manage change and gain stakeholder trust.

- Performance Metrics for Blended Workflows: Traditional performance measurement systems do not adequately capture the complex interactions between humans and machines. There is a need for new metrics that reflect productivity, quality, innovation, and human factors in Industry 5.0 environments.

Addressing these research gaps is essential to fully realise the transformative potential of Industry 5.0, ensuring that technological advances align with human and environmental priorities. Future research should adopt multidisciplinary approaches to develop integrated strategies that foster innovation, sustainability, and ethical collaboration between humans and machines.

6. Implications and Future Research Agenda

6.1 Theoretical Implications

First, our results contribute theoretically to the body of work on institutional theory. Our framework highlights that adopting a learning strategy involves intentionally selecting suppliers committed to sustainability. This aligns with Chandler and Hwang's (2015) research, which combined institutional theory with insights from learning theory to explain organisational adoption strategies. Their findings demonstrate that integrating these theories enables organisations to generate crucial questions, reshape structures and practices, and improve understanding of how sectoral, organisational, and innovation characteristics affect adoption strategies and their evolution.

Second, concerning organisational human capability strategy, our framework illustrates the intersection between sustainability-focused technologies and the necessary technical and managerial skills. This complements the findings of Messerschmidt and Hinz (2013), who promoted an integrated institutional theory and organisational capability perspective on grid computing adoption. They emphasised that organisational technology adoption is significantly influenced by institutional pressures rather than solely internal or technological factors.

Third, our framework indicates that a leapfrogging strategy must recognise challenges posed by integrating collaborative robots (cobots) within the supply chain 5.0 framework and identify relevant regulations. Alignment should extend to governance structures and evolving electronic contracting practices among supply chain participants. This corresponds with Benner's (2019) research on smart specialisation, which illustrated how institutional discovery and change can facilitate leapfrogging. Benner found that institutional pressures and credibility foster leapfrogging, promoting new cooperative routines.

Fourth, our framework emphasises the cultural and cognitive dimensions of disruption mitigation strategies within Industry 5.0 contexts. This resonates with Neupane's (2017) research on supply chain risk reduction mechanisms. Neupane argued that managing these risks involves normative and cultural-cognitive tasks, heuristics, and mimicry. Adopting these operational practices thus becomes essential for effective risk mitigation.

Finally, our framework describes sustainable operations strategy as a socio-technological phenomenon within agile and adaptive contexts. This aligns with Vandergert *et al*. (2016), who explored adaptive governance through institutional theory in urban management. They concluded that institutional theory effectively supports adaptive governance, enhancing urban resilience and sustainability strategies.

6.2 Practical Implications

Figure 6 illustrates the connections among the established strategies. The core node symbolises the primary objective of combining human-centric, resilient, and sustainable methods. Each of the five strategies both affects and is affected by this transformation. Firstly, learning enhances knowledge, best practices, and ongoing improvement concerning other strategies and the overall transition process. It also derives benefits from experiences obtained in other domains, such as strategies for mitigating disruptions or the implementation of new technologies. Secondly, Organisational Human Capability is influenced by continuous Learning processes,

including workforce training and knowledge management. A skilled and adaptable workforce is essential for all other strategies, especially Leapfrogging and Disruption Mitigation.

Thirdly, Leapfrogging signifies the implementation of cutting-edge technologies or innovative processes, occasionally skipping over gradual steps. This strategy depends on a solid skill set (Organisational Human Capability) and a commitment to continuous knowledge enhancement (Learning). In turn, successful leapfrogging offers insights for Disruption Mitigation and Sustainable Operations by rapidly introducing innovative solutions. Fourthly, Disruption Mitigation focuses on creating solid contingency plans, adaptable supply chain frameworks, and swift response strategies. It draws support from insights gained through Leapfrogging, such as utilising new technologies for risk management, and relies on Organisational Human Capability to effectively put these strategies into practice. Lastly, Sustainable Operations prioritises minimising environmental impact, ensuring responsible sourcing, and upholding social accountability. It is shaped by all previous strategies, such as learning to implement eco-friendly practices, using new technologies to minimise waste, and establishing resilient processes that support sustainability.

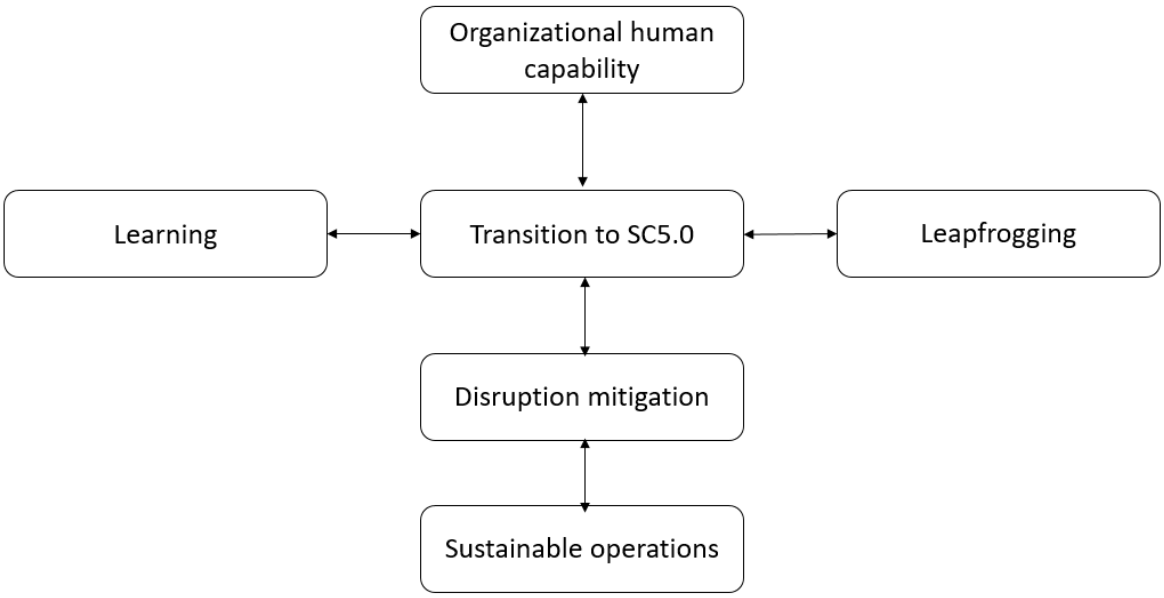

Figure 6: Relationships among the strategies

Within the scope of our study, two main industrial applications are identified in the literature. The first is in healthcare systems, while the second refers to the transition from agriculture 4.0 to agriculture 5.0. We highlight here the main practical benefits for each. The first industrial application relates to healthcare. Nayeri *et al.* (2023) examined adaptable supply chain 5.0 within healthcare systems, stating that sustainability is important in these systems. With Industry 5.0, industrial leaders must move towards using cutting-edge technologies such as 3D printing and robotic manufacturing to improve supply chain efficiency. Moreover, technologies such as blockchain and smart contracts can improve collaboration, boosting the supply chain's agility. For instance, Siemens Healthineers has developed an AI-based model for chest

diagnosis (Park *et al*. 2020). By introducing these strategies, managers can gain a competitive advantage and increase profit. From the perspective of human-centricity, managers should focus on employee and customer well-being and consider their needs and preferences in the decision-making process. This can result in a more customer-oriented and employee-friendly supply chain, which can improve the overall performance and sustainability of the business. In terms of resilience, managers can use advanced technologies such as to improve the flexibility and agility of their supply chain to ensure the continuity of their business operations.

The second is related to agriculture 5.0. Zambon *et al*. (2019) note that Agriculture 5.0 can predict autonomous systems in a rural environment, which could reduce the costs of developing autonomous agricultural machinery. Companies such as Trimble, AgVerdict Inc. or Decisive Farming Corp. have patented their commercial solutions for smart farming (Saiz-Rubio and Rovira-Más 2020). It is important to change farmers' mindsets to produce a sustainable and effective production system that will have longevity. This implies that sustainability and human-centric perspectives should be considered in the development and implementation of smart farming technologies and practices.

6.3 Limitations and future research agenda

The systematic literature review on supply chain 5.0 strategies reveals methodological limitations such as publication bias due to reliance on major databases, potentially excluding grey literature and non-English studies (Dubey *et al*., 2022). Future research should prioritise empirical methodologies—like case studies and longitudinal analyses—to assess the real-world impacts of technologies such as AI, IoT, and blockchain on supply chain performance. Additionally, further investigation into cross-sectoral differences, sustainability integration, and the interplay between digital transformation and supply chain resilience is essential (Kamble *et al*., 2020; Queiroz *et al*., 2021).

There are several strategic implications related to Industry 5.0, which show promise for future research. Seven research pathways for the related strategies were identified:

- Triple-R strategy: Saisridhar *et al*. (2023) determined that further research is required to increase understanding of the social implications of Industry 5.0 for supply chain resilience and to develop strategies for managing disruptions. To that end, a simulation is a useful tool for assessing supply chain resilience, robustness, and responsiveness.
- Privacy strategies: This is related to the tracking and tracing systems used for transport and logistics purposes. Jandl *et al*. (2021) discussed two types, data-oriented and process-oriented strategies. The authors note that privacy issues are a worthwhile application and one of the foremost challenges for Industry 4.0 and healthcare.
- Business strategy: Alvarez-Aros and Bernal-Torres (2021) investigated the main aspects of emerging technologies and technological competitiveness of Industry 4.0 and Industry 5.0 in emerging and developed economies and discussed the relevant implications for intangibles management strategies as well as business model strategies. Further research is required to explore how the organisational approach of business models incorporates and integrates the three pillars of Industry 5.0 within supply chain knowledge management.
- Marketing strategy: Human-machine collaboration leads to flexible marketing strategies (Alojaiman, 2023). However, there remains a gap in identifying the impact of Industry 5.0 products on consumer purchasing and behaviour. Further research is required to connect marketing strategies to the key features of Operations 5.0.

- ∇ Fleet management strategies: Aybo *et al*. (2023) noted that the COVID-19 crisis has reinforced the need for businesses to use more resilient SCM strategies. It is predicted that optimising the expectations of creating logistic operations might be covered by the systems managed with fleet traffic management and navigation software. This can be supported by drones and human-like collaborative robots, shifting from the supply chain to developing blockchain. Indeed, fleet management is crucial to the success of the distribution channel, primarily in critical sectors such as the food industry (Fares *et al*., 2023a). Supply chain logistics should also be operated rapidly to meet the demands of e-trade customers under the quarantine conditions, given the impact of the COVID-19 crisis in 2020. Research is needed for potential applications of supply chain 5.0 technology for recovery strategies during disruptions.
- ∇ Manufacturing strategy: Leng *et al*. (2022) argued that a resilient manufacturing strategy based on the Industrial Internet of Things (IIoT) networks is necessary to facilitate production and supply chain recovery. Resilient manufacturing is an objective in Industry 5.0 to achieve sustainable development goals during pandemics. Research is required to investigate the nexus of the Internet of Things and cyberattacks in light of this vision.
- ∇ Supply chain innovation strategy: Yuan *et al*. (2022) explored the effects of supply chain innovation announcements on shareholder value within the context of Industry 4.0 and Industry 5.0. They discovered that supply chain innovation announcements positively affect shareholder value. Research is needed to investigate the stock market and financial indicators, given the other factors that interfere with the stock market, such as news or social media, mainly in complicated settings such as multi-tier networks (Fares *et al*., 2023b).

The adoption of Supply Chain 5.0 needs supportive government policies that promote the integration of advanced digital technologies while addressing cybersecurity and data privacy concerns. Key interventions include financial incentives like grants and tax breaks to encourage the use of technologies such as AI, IoT, and blockchain (Dubey *et al*., 2022). Additionally, establishing regulatory standards and fostering public-private partnerships can facilitate secure data exchange across supply chains (Kamble *et al*., 2020). Workforce development and R&D funding are crucial to building the digital skills and innovation ecosystem needed for these transformations (Queiroz *et al*., 2021).

7. Conclusions

The strategic implications of Industry 5.0 are a new topic within supply chain management for both scholars and practitioners. This study has comprehensively reviewed the research obtained from both Scopus and Web of Science databases. Since 2019, no significant journal outlet has published most of these records. In terms of regional scope, the focus was on Iran, Turkey, Malaysia, China, and Europe. Through network-based bibliometric analysis, five key strategies are identified as significantly influencing supply chain 5.0 developments. These strategies include the learning strategy, organisational human capability development, leapfrogging and industry-specific strategies, disruption mitigation, and strategies aimed at sustainable development and operations. Future research should explore seven promising strategies: the triple-R (reduce, reuse, recycle) strategy, privacy, business, marketing, fleet management, manufacturing, and innovation in supply chain strategy. From a practical perspective, Agriculture 5.0 and healthcare are significant in the current literature concerning strategies for supply chain Industry 5.0. However, there is a gap in real-life case studies and applications across both the industrial and service sectors.

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Appendices

Appendix A: Comparative table of the literature

Paper	Title	Type	Key insights
Kumar and Singh (2025)	Decoding Supply Chain 5.0 Adoption by Grey Influence Analysis: What Barriers and Enablers Lie Within?	Empirical	The paper addresses the adoption of Supply Chain 5.0, emphasising its importance in project success and risk minimisation. It explores potential enablers that can overcome significant barriers, particularly in modern industries within developing economies.
Santiago *et al*. (2025)	Corporate social responsibility and circular economy integration framework within sustainable supply chain management: Building blocks for industry 5.0	Empirical	The paper underscores the need to merge corporate social responsibility (CSR) and the circular economy (CE) into sustainable supply chain management (SSCM). This integration is seen as essential for organisations transitioning into the I5.0 era.
Boudouaia *et al*.(2024)	Supply chain 5.0: Vision, challenges, and perspectives.	Conceptual	The paper highlights that modern supply chains face significant challenges such as limited visibility, trust issues among stakeholders, and insufficient transparency and traceability. Current systems lack a comprehensive framework to address these complexities, which has led researchers to explore new paradigms. Supply Chain 5.0 is presented as a transformative approach that integrates advanced technologies and strategic foresight to overcome these obstacles, ensuring greater resilience and adaptability.
Hossain *et al*. (2024)	From Theory to Practice: Leveraging Digital Twin Technologies and Supply Chain Disruption Mitigation Strategies for Enhanced Supply Chain Resilience	Empirical	The study fills a research gap by exploring the roles of digital twin (DT) technologies and supply chain disruption mitigation (SCDM) strategies in enhancing supply chain resilience (SCR)

	with Strategic Fit in Focus		
Saisridhar *et al*. 2023	Assessing supply chain responsiveness, resilience and robustness (Triple-R) by computer simulation: a systematic review of the literature	Conceptual	The authors found that computer simulation effectively assesses supply chain resilience, robustness, and responsiveness. They identified factors impacting performance, such as disruptions, demand variability, and lead times, and highlighted the need for more research on simulation for evaluating supply chain Triple-R in complex resource supply chains.
Brauner *et al*. Ziefle (2022)	Beyond playful learning-Serious games for the human-centric digital transformation of production and a design process model	Empirical	The study highlights the importance of designing human-centric industrial user interfaces to enhance collaboration among operators and stakeholders in production. Industry 5.0 promotes a value-oriented framework emphasising resilience, sustainability, and human-centricity, as production systems are increasingly complex and disruptions can lead to significant consequences.
Rahman *et al*. 2019	Digitalisation and leapfrogging strategy among the supply chain members: Facing the GIG economy and why should logistics players care?	Empirical	The application of Industry 5.0 concepts, including digitalisation and mobile marketing, is increasingly important for logistics companies. These strategies enhance visibility for both customers and competitors, enabling logistics players to better position themselves in the market. By leveraging these technologies, businesses can improve their operations and foster stronger connections with their audience.
Frederico (2021)	From Supply Chain 4.0 to Supply Chain 5.0: Findings from a Systematic Literature Review and Research Directions	Conceptual	The study discusses how transitioning to this human-centric paradigm poses challenges in integrating disruptive technologies while addressing ethical, social, legal, and regulatory issues.
Aybo *et al.,* 2022	THE NECESSITY OF TRANSITION FROM INDUSTRY 4.0 TO INDUSTRY 5.0: SWOT ANALYSIS OF TURKEY'S SCM STRATEGY	Empirical	The study highlights that businesses must interconnect logistics and production operations to achieve a fully automated intralogistics process. It predicts that expectations for optimising logistics will be met through fleet traffic management, navigation software, drones, collaborative robots, and 5G technologies, shifting from supply chain to blockchain systems. However, it does not address the challenges of transitioning from Industry 4.0 to Industry 5.0 in logistics.

Appendix B: Figures of Web of Science Papers

Author Full Names	Article Title	Author Keywords	Cited Reference Count
Maric, Josip; Opazo-Basaez, Marco; Vlacic, Bozidar; Dabic, Marina	Innovation management of three-dimensional printing (3DP) technology: Disclosing insights from existing literature and determining future research streams	3D print; Additive manufacturing; Innovation management; Systematic literature review; Multi correspondence analysis	209
Saisridhar, Pranesh; Thuerer, Matthias; Avittathur, Balram	Assessing supply chain responsiveness, resilience and robustness (Triple-R) by computer simulation: a systematic review of the literature	Supply chain responsiveness, supply chain resilience, supply chain robustness; computer simulation; systematic literature review	198
Hassoun, Abdo; Ait-Kaddour, Abderrahmane; Abu-Mahfouz, Adnan M.; Rathod, Nikheel Bhojraj; Bader, Farah; Barba, Francisco J.; Biancolillo, Alessandra; Cropotova, Janna; Galanakis, Charis M.; Jambrak, Anet Rezek; Lorenzo, Jose M.; Mage, Ingrid; Ozogul, Fatih; Regenstein, Joe	The Fourth Industrial Revolution in the Food Industry-Part I: Industry 4.0 Technologies	Autonomous robots, artificial intelligence, big data, blockchain, digital transformation, smart sensors, Internet of Things	150
Leng, Jiewu; Chen, Ziying; Huang, Zhiqiang; Zhu, Xiaofeng; Su, Hongye; Lin, Zisheng; Zhang, Ding	Secure Blockchain Middleware for Decentralised IIoT towards Industry 5.0: A Review of Architecture, Enablers, Challenges, and Directions	Decentralized Industrial Internet of Things; Blockchain middleware; data security; Industry 5; 0; Resilient manufacturing	126
Zambon, Ilaria; Cecchini, Massimo; Egidi, Gianluca; Saporito, Maria Grazia; Colantoni, Andrea	Revolution 4.0: Industry vs. Agriculture in a Future Development for SMEs	agriculture 4.0; industry 4.0; SMEs; application research; supply chain; open source	126
Nayeri, Sina; Sazvar, Zeinab; Heydari, Jafar	Towards a Responsive Supply Chain based on the Industry 5.0 Dimensions: A Novel Decision-making Method*	Responsive supply chain; Supply chain 5; 0; Industry 5; Medical devices; Stochastic best -worst method	119

Kumar, Subodha; Mallipeddi, Rakesh R.	Impact of cybersecurity on operations and supply chain management: Emerging trends and future research directions	cybersecurity; Industry 4; 0; Industry 5; 0; information and communication technologies; production and operations management	107
Brauner, Philipp; Ziefle, Martina	Beyond playful learning games for the human-centric digital transformation of production and a design process model	Serious games; Industry 4; 0; Human factors; Game-based learning; Knowledge and skills; Production engineering	106
Modgil, Sachin; Singh, Rohit Kumar; Agrawal, Soni	Developing human capabilities for supply chains: an Industry 5.0 perspective	Human capital; Industry 5; 0; Supply chain; AHP; DEMATEL	101
Frederico, Guilherme F.	From Supply Chain 4.0 to Supply Chain 5.0: Findings from a Systematic Literature Review and Research Directions	Supply Chain 5; 0; Supply Chain 4; 0; Industry 5; 0; Industry 4; 0; literature review; research agenda	85

Appendix C: Word cloud of the selected papers

Appendix D: Diagnostic questions

Criteria	Diagnostic Question
Sustainability	
Sustainable Suppliers	Do we evaluate suppliers based on environmental and social performance?
Machine-Data-Human Synergy	Are our systems designed to facilitate collaboration between humans, machines, and data?
E-Contracts	Do we use smart contracts or digital agreements to enhance traceability and automation?
Sustainable Finance	Are our investment and procurement decisions aligned with ESG (Environmental, Social, Governance) principles?
Socio-Technological Impact	Do we assess the social and environmental implications of adopting new technologies?
Human centricity	
Knowledge Transfer	Are there formal mechanisms for sharing operational and strategic knowledge?
Technical & Managerial Skills	Have we assessed and addressed gaps in digital, managerial, and technical skills among staff?
Cobots Regulation	Do we have clear internal policies and safety standards for using collaborative robots?
Expert Involvement	Do we include cross-functional experts in supply chain innovation projects?
Employee & Customer Focus	Do we regularly assess employee well-being and customer satisfaction as strategic metrics?
Resilience	
Turbulent Market Readiness	Do we have contingency plans for supply/demand shocks and market volatility?
Technological Landscape Awareness	Do we monitor and adapt to emerging technologies relevant to our supply chain?
Governance	Are responsibilities, policies, and decision-making processes well-defined and agile?
Monitoring & Viability	Do we use real-time data to monitor operations and predict disruptions?
Agile Simulation	Have we implemented digital twins or simulation tools for scenario analysis?