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Bibliometric Analysis of Digital Twins (DTS) Application for Improving Sustainable Logistics in Supply Chains

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Abstract
In recent years, research into Digital Twins (DTs) for enhancing supply chains through sustainable logistics has shown remarkable growth and diversification. Starting with a single publication in 2018, interest surged in subsequent years, reaching a substantial peak of 90 publications in 2023. Despite a slight decline in 2024, the overall trend highlights sustained interest and investment in exploring DT applications for optimizing supply chains and promoting sustainability. Leading authors in the field, such as George Guoquan Huang, Hao Yu, and Dmitry Aleksandrovich Ivanov, represent a diverse global landscape, indicating widespread engagement in this interdisciplinary field. Moreover, an analysis of publication distribution across countries identifies China as a prominent contributor, followed closely by the United States, France, and Italy. The citation impact and influence of journals such as the "Journal of Cleaner Production" and "Technological Forecasting and Social Change" underscore their pivotal role in advancing knowledge in this domain. Additionally, co-authorship and citation analyses underscore the importance of collaborative efforts among researchers, highlighting the significance of teamwork in scholarly innovation. Keyword analysis reveals prevalent research themes such as "digital twin," "Internet," and "artificial intelligence," providing valuable insights into key areas of focus within the field. Overall, this bibliometric study offers comprehensive insights into the evolving landscape of DT research, providing valuable perspectives for academics, practitioners, and policymakers interested in leveraging DTs for sustainable supply chain management.

Keywords: Digital Twins, Supply Chain, Sustainable Logistics, Technology, Digitalization, Bibliometric Analysis, VOSviewer, etc.

Introduction

Over the past decade, technological advancements such as Industry 4.0, blockchain, and 3D printing have driven the digitization of industries globally, promising enhanced efficiency and reduced costs (Khan et al., 2015; Rosin et al., 2020; Sabbagh et al., 2012). However, this transition also poses challenges such as legal complexities and skill shortages (Parviainen et al., 2017). Supply chain disruptions like COVID-19 and natural disasters further highlight the need for resilience (Chowdhury et al., 2021; Guan et al., 2020; Gunessee & Subramanian, 2020). To address these challenges, Digital Twins (DTs) have emerged as transformative solutions, offering virtual representations of physical assets for simulation and

decision-making (Glaessgen & Stargel, 2012; Rosen et al., 2015). In logistics and supply chain management, DTs enhance operational excellence and inform decision-making (Centre for Digital Built Britain, 2022). The concept of Digital Twins (DTs) has been introduced by van der Burg, S.; Kloppenburg, S.; Kok, E.J.; van der Voort, M. (2021) and Neethirajan, S.; Kemp, B. (2021) as virtual replicas of physical systems, emphasizing their components: digital definition, operational data, and an information model. Melesse, T.Y.; Di Pasquale, V.; Riemma, S. (2021) highlight DTs' broad applicability across sectors. Koulouris, A.; Misailidis, N.; Petrides, D. (2021) underline their optimization potential in various aspects.

However, despite their potential, challenges like data privacy and computational limitations hinder DT implementation (Abideen et al., 2021; Cirullies & Schwede, 2021). Overcoming these challenges is vital for realizing DTs' benefits in supply chain visibility, resilience, and sustainability. This paper presents a bibliometric analysis focused on the application of Digital Twins in improving supply chain through sustainable logistics. By examining the evolution of literature in this field, we aim to address key research questions, including the total number of articles, growth trends, worldwide distribution, citation impact of relevant journals, prominent researchers, and relatedness among researchers. Through this analysis, we seek to shed light on the current state and future directions of research in this domain, ultimately contributing to the advancement of knowledge and practice in leveraging DTs for sustainable supply chain management.

Research Questions

1. What are the total number of articles, growth trend and worldwide distribution in the field applications of Digital Twins in improving Supply chain through Sustainable Logistics in terms of emerging and advanced nations?
2. Which are those journals on applications of Digital Twins in improving Supply chain through Sustainable Logistics that have the most citation impact?
3. Who are the most prominent researchers in the field of applications of Digital Twins in improving Supply chain through Sustainable Logistics that have most citations?
4. What is the relatedness of researchers in applications of Digital Twins in improving Supply chain through Sustainable Logistics?

Literature Review

Recent literature highlights significant advancements in technologies such as Internet of Things (IoT), cloud computing, and blockchain, which have substantially expanded the potential applications of digital twins in supply chain management. Studies emphasize the importance of a comprehensive digital supply chain twin that encompasses both physical assets (things) and human elements across the entire supply chain network. Responding to these findings, Kamble et al. (2022) propose a sustainable digital twin implementation framework tailored specifically for supply chains, aiming to enhance visibility, efficiency, and sustainability throughout the supply chain ecosystem. Le and Fan (2024) provide a comprehensive review of current Digital Twins (DTs) for Logistics and Supply Chain Systems (LSCS), offering a conceptual framework, identifying research potentials and challenges, and discussing future DT computation. Meanwhile, Bargavi and Mathivathanan (2023) elucidate digital twins' significance in supply chain management, detailing their types, benefits, and implementation challenges, along with a ten-step implementation process for managers to optimize supply chains and innovate in the digital era. Zarnitz and Straube (2023) scrutinize digital twins' role in Logistics and Supply Chain Management (LSCM), defining "digital supply chain twin," outlining technical prerequisites, and identifying key application domains, while emphasizing the need for further inquiry to address limitations and research gaps.

Furthermore, Le and Fan (2024) stress the necessity of a conceptual framework for DTs in LSCS to enhance decision-making and industry planning, envisioning a future of transparent and resilient DTs through advanced analytics and modeling techniques. Despite the growing importance of green recruitment, empirical studies in this area remain limited, prompting a systematic review and bibliometric analysis of literature on "Applications of Digital Twins in improving Supply chain through Sustainable Logistics" to guide future research and contribute to the advancement of knowledge in this field.

Methodology

The study used the Systematic Bibliometric Analysis for understanding and analyzing the literature of digital twins in improving the supply chain management through sustainable logistics practices.

Collection of Data

The study utilizes published data from the Dimensions database, renowned for its extensive collection of peer-reviewed papers. Data from UGC Journals Group-II (2018-2024) were scrutinized based on various criteria like nations, journals, fields, authors, and affiliations. Digital Twins in improving Supply chain through Sustainable Logistics network research was conducted post-assessing keyword frequency using the search criteria "digital twins" AND "Supply Chain" AND "sustainable logistics". The sources preferred was "Commerce, Management, Tourism and Services OR Transportation OR Logistics and Supply Chains OR Urban and Regional Planning OR Engineering OR Built Environment and Design". All relevant data, including titles and abstracts, were extracted from Dimensions and imported into VOSviewer for analysis. VOSviewer allows examination of relationships among authors, nations, citations, and frequently used phrases in the articles, offering insights into the article's content and connections.

Main Information Regarding the Collection

93 reputable peer-reviewed publications have published 141 articles about " Digital Twins in improving Supply chain through Sustainable Logistics " that were written by 440 scholars from 38 countries with citations mean of 31.23 and span a variety of fields like business, management, and accounting. Since 864 authors contributed to the total, author collaboration is growing. Authors per documents are valued 2.43 while documents per authors are valued 0.41. VOSviewer, an open-source R-package software, was specifically used for the bibliometric investigation (Aria & Cuccurullo, 2017).

Results

Bibliometric analysis is a quantitative method for assessing scientific publications, gauging research production, dissemination, and impact through statistical techniques. It aids in evaluating research patterns, scholar influence, and organizational contributions. Employing mathematical and quantitative methodologies, bibliometric analysis predicts future research trajectories, as seen in studies on "green recruitment and selection" (Yu et al., 2017, 2018). By analyzing published data on authorship, affiliations, citations, and keywords, bibliometrics offers insights into research trends (Norton, 2001). Technology-driven researcher efficacy is tracked over time, with tools like "VOSviewer" generating bibliometric maps to visualize authorship and publication relationships using co-citation and co-occurrence data.

Number of Publications

Research in Digital Twins aimed at enhancing supply chains through sustainable logistics has seen notable trends over the past few years. In 2018, there was a solitary publication addressing the integration of Digital Twins within supply chain contexts to bolster sustainability efforts. Following a quiet period in 2019 and 2020, interest appeared to rekindle in 2021, with a single publication signaling a potential resurgence in research focus. However, the most substantial growth came in 2022, where publications surged to 30, indicating a burgeoning recognition of Digital Twins' potential to optimize supply chain operations while aligning with sustainability goals. This momentum continued to skyrocket in 2023, with a remarkable increase to 90 publications, suggesting a maturing field with heightened research activity, likely spurred by demonstrated benefits in sustainable logistics practices. Although there was a slight dip in 2024 with 33 publications, the overall trajectory underscores sustained interest and investment in exploring Digital Twins' applications for enhancing supply chain efficiency and sustainability.

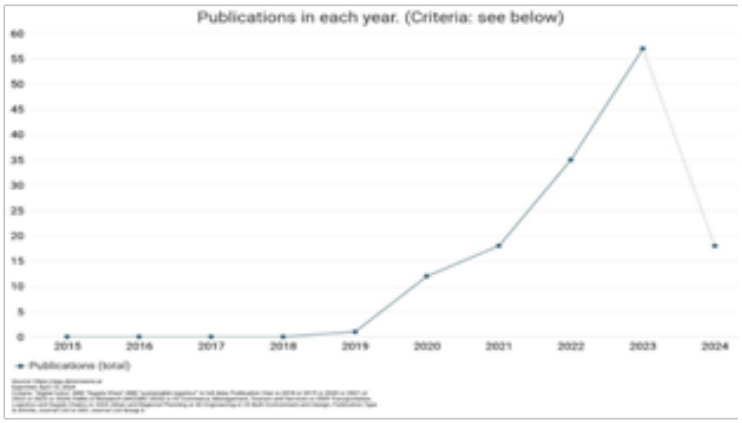

Figure 1 Publication Over the Period

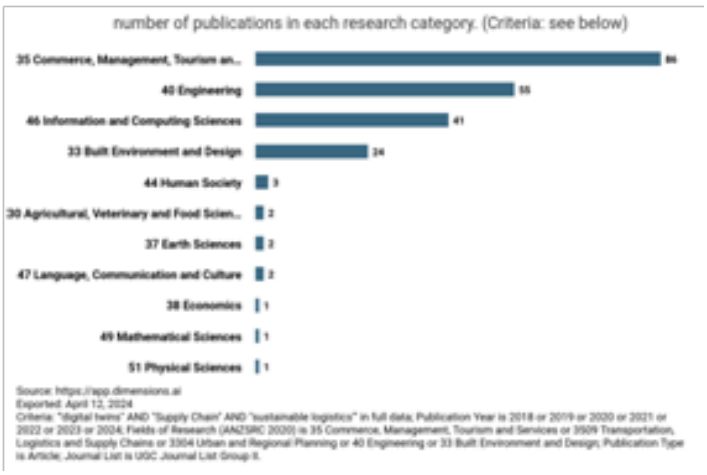

Figure 2 No. of Publications in Each Research Category

Top Ten Authors with their Contributions

The top 10 authors in the field are distinguished by their contributions to research in Digital Twins within supply chain and logistics, along with their associated citation metrics. George

Guoquan Huang, from Hong Kong Polytechnic University, China, leads with four publications, each garnering a mean of 1.5 citations. Hao Yu, affiliated with UiT The Arctic University of Norway, Norway, follows closely with three publications, accumulating 81 citations, averaging 27 per paper. Dmitry Aleksandrovich Ivanov, representing Berlin School of Economics and Law, Germany, also boasts three publications, with a notable total of 169 citations, averaging 56.33 citations per paper. Other notable contributors include Rodrigo Goyannes Gusmão Caiado from Pontifical Catholic University of Rio de Janeiro, Brazil, and Jose Arturo Garza-Reyes from the University of Derby, United Kingdom, both with two publications each and remarkably high citation counts, averaging 276 citations per paper. These authors represent a diverse global landscape of academic institutions, demonstrating the widespread interest and engagement in the intersection of Digital Twins, supply chain optimization, and sustainable logistics.

Table 1 Top 10 Authors with their Contribution

S. No.	Name	Organization, Country	Publications	Citations	Citations Mean
1	George Guoquan Huang	Hong Kong Polytechnic University, China	4	6	1.5
2	Hao Yu	UiT The Arctic University of Norway, Norway	3	81	27
3	Dmitry Aleksandrovich Ivanov	Berlin School of Economics and Law, Germany	3	169	56.33
4	Manu Sharma	Graphic Era University, India	2	74	37
5	Fabio Sgarbossa	Norwegian University of Science and Technology, Norway	2	6	3
6	Mengdi Zhang	Nanjing University of Posts and Telecommunications, China	2	4	2
7	Rodrigo Goyannes Gusm Ão Caiado	Pontifical Catholic University of Rio de Janeiro, Brazil	2	552	276
8	Valdas Jankunas	Klaipėda University, Lithuania	2	7	3.5
9	Rohit Agrawal	Indian Institute of Management Calcutta, India	2	89	44.5
10	Jose Arturo Garza-Reyes	University of Derby, United Kingdom	2	552	276

Number of Publications Per Country

The data provides an overview of the number of publications from various countries. Notably, China leads with 44 publications, followed closely by the United States with 25 publications, and France and Italy with 26 publications each. India and Poland also contribute significantly with 28 and 19 publications respectively. Other notable contributors include Spain with 21 publications, Germany with 10 publications (though “Gemany” appears to be a typo and should likely be merged with Germany), and Sweden with 13 publications. Additionally, several countries such as Brazil, Lithuania, and Morocco contribute moderately with 12, 9, and 9 publications respectively. On the other hand, some countries have lower publication counts, such as Canada, Ireland, Bangladesh, and Czechia, each with 3 or fewer publications. This distribution of publications among different countries offers insights into the global distribution of research output and scholarly activity across various regions.

Figure 3 Heat Map - No. of Publications Per Country

Top Ten Sources

Table 2 Top 10 Source Titles

S. No.	Name	Publications	Citations	Citations Mean
1	Sustainability	32	393	12.28
2	Journal of Cleaner Production	8	1,105	138.13
3	The International Journal of Logistics Management	7	101	14.43
4	International Journal of Production Research	4	329	82.25
5	Journal of Open Innovation: Technology, Market, and Complexity	4	62	15.5
6	Business Strategy and the Environment	4	225	56.25
7	Applied Sciences	4	41	10.25
8	Technological Forecasting and Social Change	3	277	92.33
9	Journal of Marine Science and Engineering	3	24	8
10	International Journal of Production Economics	3	15	5

The data presents information on the number of publications, citations, and the average citation count for ten different journals. Among them, the "Journal of Cleaner Production" stands out with 8 publications and an impressive total of 1,105 citations, resulting in a high average citation count of 138.13 per publication. Similarly, "Technological Forecasting and Social Change" demonstrates a notable impact with 3 publications but a substantial citation count of 277, resulting in an average of 92.33 citations per publication. Other journals such as "Sustainability" and "International Journal of Production Research" also have considerable citation counts, with 393 and 329 citations respectively, but lower average citation counts compared to the top performers. Conversely, journals like "Journal of Marine Science and Engineering" and "International Journal of Production Economics" have fewer publications and lower citation counts, resulting in lower average citation counts per publication. Overall, these metrics provide insights into the impact and influence of these journals within their respective fields of study.

Co-Authorship Analysis

The analysis of researcher relatedness is conducted by evaluating the number of co-authored publications, which serves as an indicator of collaborative engagement within the academic community. In total, there are 29 researchers included in the analysis, forming 5 distinct clusters based on their collaborative patterns. Across these clusters, a total of 75 co-authorship links are identified, representing the extent to which researchers collaborate with each other in producing scholarly works. This collaborative effort results in a cumulative total of 78 co-authorships, underscoring the significance of teamwork and shared contributions in academic research. These clusters offer insights into the interconnectedness and collaborative networks within the academic community, fostering knowledge exchange and advancement across various fields of study.

Figure 4 Co-Authorship Analysis - Network Diagram

The co-authorship analysis reveals distinct clusters of researchers based on their collaborative efforts in publications. In Cluster 1 (Red), led by top researcher Eric Ballot from PSL University, there are 6 co-authorship links, resulting in a total of 6 co-authorships across 2 publications. Cluster 2 (Green), spearheaded by George Guoquan Huang from Hong Kong Polytechnic University, boasts 15 co-authorship links, indicating a total of 17 co-authorships from 4 publications. Cluster 3 (Blue) features a group of researchers including Kai Zhang and Kuo Zhao from Hong Kong Polytechnic University, along with researchers from Jinan University, collectively accumulating 6 co-authorship links and 6 total co-authorships from 1 publication. In Cluster 4 (Yellow), Saurabh Pratap from Indian Institute of Technology Varanasi emerges as the top researcher, with 10 co-authorship links resulting in 10 total co-authorships across 2 publications. Meanwhile, Cluster 5 (Violet), led by Dmitry Aleksandrovich Ivanov from Berlin School of Economics and Law, exhibits 6 co-authorship links, reflecting 6 total co-authorships distributed over 3 publications. These clusters highlight the collaborative endeavors among researchers, underscoring the importance of teamwork and shared expertise in advancing scholarly knowledge and innovation.

Citation Analysis

The analysis of researcher relatedness is conducted by examining the frequency with which researchers cite each other. In total, there are 122 researchers included in the analysis, collectively forming 10 distinct clusters based on their citation patterns. These clusters reflect the interconnectedness and collaboration among researchers within various academic fields. Across

these clusters, there are a total of 446 citation links, indicating the extent to which researchers reference each other's work. This interconnectedness contributes to the accumulation of knowledge and the dissemination of research findings within academic communities. Moreover, the cumulative total of citations across all researchers amounts to 516, underscoring the impact and influence of their collective body of work within their respective fields. Overall, this analysis sheds light on the collaborative networks and scholarly interactions that shape the advancement of research and innovation.

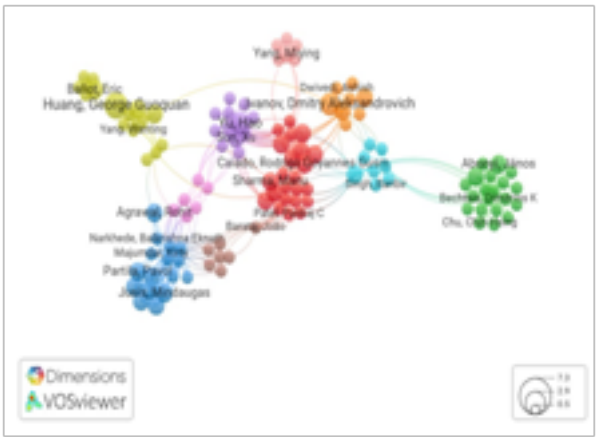

Figure 5 Citation Analysis - Network Diagram

The citation analysis reveals diverse clusters of researchers, each characterized by varying levels of citation impact and publication output. In Cluster 1 (Red), Vinit Parida from Luleå University of Technology garners 15 citation links, with a total of 18 citations across 2 publications. Cluster 2 (Green) is led by Dimitrios P Vlachos from Aristotle University of Thessaloniki, with 19 citation links and 20 total citations from 1 publication. Cluster 3 (Blue) features a group of researchers including Katarzyna Szopik-Depczyńska from University of Szczecin, Izabela Dembińska from Maritime University of Szczecin, Kirty Majumdar from Jadavpur University, and Giuseppe Ioppolo from University of Messina, collectively accumulating 20 citation links and 27 total citations from 1 publication. In Cluster 4 (Yellow), George Guoquan Huang from Hong Kong Polytechnic University has 10 citation links, with 12 total citations stemming from 4 publications. Hao Yu from UiTThe Arctic University of Norway stands out in Cluster 5 (Violet) with 19 citation links and 27 total citations across 3 publications. Cluster 6 (Cyan) highlights Agnieszka Anna Tubis from Wrocław University of Science and Technology as the top researcher, amassing 21 citation links and 21 total citations from 2 publications. In Cluster 7 (Pink), Miying Yang from Cranfield University gathers 9 citation links and 9 total citations from 2 publications. Cluster 8 (Brown) comprises researchers such as Zhou Zun from Shanghai Maritime University, Marikka Heikkilä from University of Turku, Antti Saurama, Bernardo Nicoletti, and Andrea Appolloni from Sapienza University of Rome and University of Rome Tor Vergata, collectively accumulating 8 citation links and 8 total citations from 1 publication. Finally, Cluster 9 (Orange) features Morteza Ghobakhloo from Kaunas University of Technology, garnering 20 citation links and 24 total citations from 2 publications. These clusters offer insights into the citation impact and publication productivity of researchers across different academic institutions.

Keyword Analysis

In a keyword analysis involving 4287 terms, only 80 terms met the minimum threshold of occurring at least 10 times. These 80 terms will undergo relevance scoring. From these, the most relevant terms will be chosen. By default, 60% of the most relevant items will be selected, equating to 48 terms.Cluster-1, marked in red, primarily focuses on the concept of digital twin, which occurs 14 times across the analyzed data. It holds a high relevance score of 3.5603, suggesting its significance within the cluster. The term is linked 20 times, with a total link strength of 54. Additionally, terms such as "Internet" (21 occurrences, relevance score: 2.0153) and "artificial intelligence" (13 occurrences, relevance score: 1.1674) are also prominent within this cluster, though with lower relevance scores compared to digital twin. Cluster-2, depicted in green, revolves around the term "practitioner," appearing 15 times and holding a relevance score of 1.5103. It is closely followed by "Digitalization" (15 occurrences, relevance score: 0.8597) and "Digital Technology" (15 occurrences, relevance score: 0.7639). These terms are linked with a total of 25 and 27 links, with link strengths of 81 and 72, respectively. Cluster-3, represented in blue, highlights the term "circular economy," which appears 10 times and holds a relevance score of 1.2705. It is linked 25 times with a total link strength of 50. Additionally, "Supply Chain Management" is prevalent within this cluster, occurring 25 times with a relevance score of 0.3918 and linked 16 times with a total link strength of 66.

Figure 6 Citation Analysis - Network Diagram

Discussion

Research in Digital Twins for sustainable logistics and supply chains has witnessed significant growth and interest, reflecting a maturing field. The surge in publications in 2022 and the subsequent exponential increase in 2023 indicate a burgeoning recognition of the potential of Digital Twins to optimize supply chain operations while aligning with sustainability objectives. The top 10 authors, exemplified by George Guoquan Huang and Dmitry Aleksandrovich Ivanov, demonstrate notable contributions and high citation counts, underscoring the impact of their work. Their diverse geographical affiliations highlight the global nature of this research, showcasing widespread engagement and collaboration in exploring this intersection. Furthermore, keyword analysis reveals prominent themes such as digital twin, practitioner, and circular economy, indicating evolving research interests and priorities within the field. This discussion suggests a growing understanding of the role Digital Twins can play in driving sustainable practices within supply chains, while also emphasizing the importance of continued research and collaboration to further advance this promising area of study.

Implications

The significant growth and interest in Digital Twins for sustainable logistics and supply chains imply a promising future for enhancing operational efficiency and environmental sustainability. By leveraging Digital Twins technology, businesses can optimize processes, reduce waste, and minimize environmental impact throughout the supply chain. The contributions of top researchers highlight key areas for further exploration and collaboration, paving the way for innovative solutions to address pressing challenges in sustainability and logistics. This implication underscores the potential of Digital Twins to revolutionize the way supply chains operate, ultimately leading to more resilient, efficient, and environmentally friendly systems.

Limitations, Conclusion and Future Research

In conclusion, the surge in research interest and contributions in Digital Twins for sustainable logistics and supply chains signifies a pivotal moment in the evolution of these fields. The remarkable growth in publications, coupled with the significant impact of top researchers, underscores the importance of advancing technology-driven solutions to address sustainability challenges. As businesses increasingly recognize the potential of Digital Twins to optimize operations and reduce environmental impact, collaboration and innovation will continue to drive progress in this area. With the diverse global engagement reflected in the top authors' affiliations and the evolving research themes highlighted by keyword analysis, the future holds great promise for leveraging Digital Twins to create more efficient, resilient, and sustainable supply chains. In light of the insights gained, it's crucial to acknowledge the limitations inherent in this study. Firstly, the reliance on data solely from Dimensions may result in the omission of pertinent sources, potentially limiting the scope of analysis. Secondly, the presence of researchers sharing identical names presents challenges in accurately attributing contributions. Lastly, the study's focus specifically on digital twins in supply chain management for sustainable logistics may restrict its generalizability to broader contexts. To mitigate these constraints, future research endeavors could expand data sources to include databases like Scopus and Web of Science for a more comprehensive overview. Additionally, integrating sociograms can provide deeper insights into the intricate interactions between various factors influencing the application of digital twins in supply chain management. By addressing these limitations, future studies can enhance the robustness and applicability of findings in advancing understanding and implementation of digital twins in supply chain optimization and sustainability.

References

1. Abideen, A. Z., Sundram, V. P. K., Pyeman, J., Othman, A. K., Sorooshian, S., 11 2021. Digital twin integrated reinforced learning in supply chain and logistics. Logistics 5, 84.
2. Bargavi, R., Mathivathanan, D. (2024). Digital Twins an Enabler of Digitalization in Supply Chain. In: K E K, V., Rajak, S., Kumar, V., Mor, R.S., Assayed, A. (eds) Industry 4.0 Technologies: Sustainable Manufacturing Supply Chains . Environmental Footprints and Eco-design of Products and Processes. Springer, Singapore. https://doi.org/10.1007/978-981-99-4894-9_11.
3. Centre for Digital Built Britain, 2022. Digital twins. Accessed 28-June-2022. URL https://www.cdbb.cam.ac.uk/research/digital-twins.
4. Chowdhury, P., Paul, S. K., Kaisar, S., Moktadir, M. A., 2021. Covid-19 pandemic related supply chain studies: A systematic review. Transportation Research Part E: Logistics and Transportation Review 148, 102271.
5. Cirullies, J., Schwede, C., 2021. On-demand shared digital twins – an information architectural model to create transparency in collaborative supply networks. Proceedings of the Annual Hawaii International Conference on System Sciences.

6. Eppinger, T.; Longwell, G.; Mas, P.; Goodheart, K.(2021). Increase Food Production Efficiency Using the Executable Digital Twin (XDT). Chem. Eng. Trans., 87, 37–42.
7. Glaessgen, E., Stargel, D., 2012. The digital twin paradigm for future NASA and US Air Force vehicles. In: 53rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference 20th AIAA/ASME/AHS Adaptive Structures Conference 14th AIAA. p. 1818.
8. Guan, D., Wang, D., Hallegatte, S., Davis, S. J., Huo, J., Li, S., Bai, Y., Lei, T., Xue, Q., Coffman, D., et al., 2020. Global supply-chain effects of covid-19 control measures. Nature human behaviour 4 (6), 577–587.
9. Gunessee, S., Subramanian, N., 2020. Ambiguity and its coping mechanisms in supply chains lessons from the covid-19 pandemic and natural disasters. International Journal of Operations & Production Management.
10. Khan, S., Khan, S., Aftab, M., 2015. Digitization and its impact on economy. International Journal of Digital Library Services 5 (2), 138–149.
11. Koulouris, A.; Misailidis, N.; Petrides, D.(2021). Applications of Process and Digital Twin Models for Production Simulation and Scheduling in the Manufacturing of Food Ingredients and Products. Food Bioprod. Process., 126, 317–333.
12. Melesse, T.Y.; Di Pasquale, V.; Riemma, S.(2021). Digital Twin Models in Industrial Operations: State-of-the-Art and Future Research Directions. IET Collab. Intell. Manuf. 20, 3, 37–47.
13. Neethirajan, S.; Kemp, B. (2021). Digital Twins in Livestock Farming. Animals, 11, 1008.
14. Rosin, A. F., Proksch, D., Stubner, S., Pinkwart, A., 2020. Digital new ventures: Assessing the benefits of digitalization in entrepreneurship. Journal of Small Business Strategy 30 (2), 59–71.
15. Sabbagh, K., Friedrich, R., El-Darwiche, B., Singh, M., Ganediwalla, S., Katz, R., 2012. Maximizing the impact of digitization. The global information technology report 2012, 121–133.
16. Sachin S Kamble, Angappa Gunasekaran, Harsh Parekh, Venkatesh Mani, Amine Belhadi, Rohit Sharma. (2022). Digital twin for sustainable manufacturing supply chains: Current trends, future perspectives, and an implementation framework, Technological Forecasting and Social Change, Volume 176. Doi. https://doi.org/10.1016/j.techfore.2021.121448.
17. Tho V. Le, Ruoling Fan. (2024). Digital twins for logistics and supply chain systems: Literature review, conceptual framework, research potential, and practical challenges. Computers and Industrial Engineering, Volume 187. https://doi.org/10.1016/j.cie.2023.109768.
18. Tho V. Le, Ruoling Fan. (2024). Digital twins for logistics and supply chain systems: Literature review, conceptual framework, research potential, and practical challenges, Computers & Industrial Engineering, Volume 187, https://doi.org/10.1016/j.cie.2023.109768.
19. Van der Burg, S.; Kloppenburg, S.; Kok, E.J.; van der Voort, M. (2021). Digital Twins in Agri-Food: Societal and Ethical Themes and Questions for Further Research. NJAS Impact Agric. Life Sci., 93, 98–125.
20. Zarnitz, S., Straube, F. (2023). Digital Twins in Logistics: Requirements, Application and Potentials. In: Schupp, F., Wöhner, H. (eds) Digitalisierungim Einkauf. Springer Gabler, Wiesbaden. https://doi.org/10.1007/978-3-658-40570-0_12.