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Digital Transformation in Supply Chain Management: A Bibliometric Analysis

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Abstract

In an era dominated by digital advancements, Supply Chain Management (SCM) is undergoing significant transformations. This study aims to outline a digitally-enabled SCM framework by examining prevalent research themes, methodologies, collaboration models, and groundbreaking contributions. Leveraging bibliometric analysis techniques, 600 articles from 2002 to 2023, sourced from 3 top databases, was conducted using CiteSpace for keyword analysis, co-citation analysis, and emerging term evaluations. The research identifies three distinct phases in this field: initial, incremental, and accelerated, with a notable surge in research activity post-2017, particularly after 2019. China, the US, and the UK are major contributors. Dominant topics include technology integration, efficiency, globalization challenges, strategic management, and sustainability. The study reveals limited collaboration among authors but highlights influential scholars. Given the centrality of DT, it emphasizes the need for interdisciplinary exploration and consideration of rapidly evolving digital paradigms in future research endeavors.

Keywords: *Digital Transformation; Supply Chain Management; Scientometric and Bibliometric Analysis; Digital Production; Industry 4.0.*

1. Introduction

Traditionally, SCM has been a specialized field focused on coordinating logistics, procurement, and operations (Preindl et al., 2020). However, the advent of the digital age has acted as a catalyst, fundamentally changing these traditional practices and generating an emerging paradigm of SCM 4.0. Importantly, this evolution goes beyond mere integration of digital tools; it marks a fundamental reimagining of the core nature of SCM. As disruptive technologies such

as blockchain, IoT, and machine learning become an integral part of modern SCM, it becomes imperative to critically assess their impact, challenges, and the future trajectory they chart (Zekhnini et al., 2022).

The advent of DT is instigating significant shifts across various facets of SCM, ranging from the intricacies of information acquisition and data analytics to the complexities of operational streamlining and sustainability imperatives (Dolgui et al., 2020). Hence, it is imperative to offer a holistic scrutiny of the manifold ramifications of DT within the domain of SCM, structured in alignment with the sequential phases of digitalization.

The integration of advanced technologies including AI, IoT, blockchain, and big data analytics in SCM has been a focus of recent academic research (Dolgui et al., 2020; Gomber et al., 2018). These technologies have enabled organizations to transition from traditional linear supply chains to more agile, transparent, connected, and responsive digital supply chain networks.

Using web text analysis and bibliometric techniques, the study aims to provide insights into research trends and guide future scholarly inquiry. By bridging the gap between academia and industry, the research offers practical guidance for organizations seeking to digitally transform their supply chain operations. Additionally, the study sheds light on the potential benefits and risks of digital supply chains, providing a framework for strategic planning and risk mitigation.

Employing CiteSpace software, the analysis aims to map the trajectory and hotspots in digital SCM research, identifying key research gaps and future areas of inquiry. Overall, the study contributes to a nuanced understanding of how digital technologies are shaping the landscape of SCM and provides valuable insights for both practitioners and academics in this rapidly evolving field.

2. Methodology Approach

This study employs bibliometric analysis as an interdisciplinary method to scrutinize and quantify scholarly literature, integrating text mining and network analysis techniques (Ball, 2017). The chosen tool, CiteSpace, is selected for its ability to simultaneously analyze data from multiple databases, including Web of Science (WoS), Scopus, and PubMed, providing a comprehensive panorama of scholarly literature.

The formulation of search criteria involved identifying key phrases and terms, incorporating advanced search functionalities across databases to accommodate keyword variability. The search query yielded a dataset of 600 articles from 2002 to July 31, 2023 [Figure1].

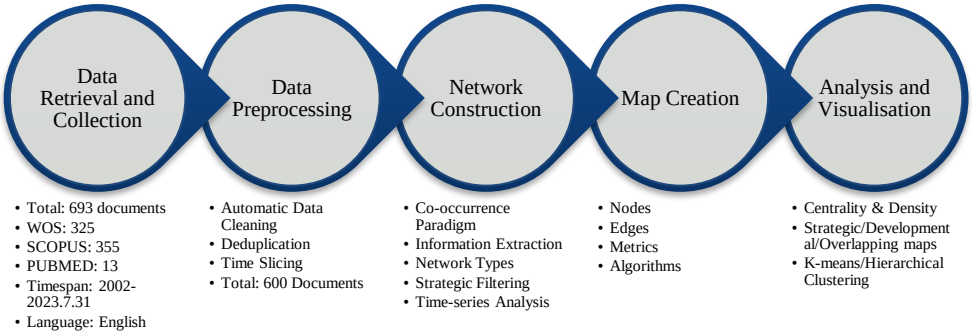

Figure 1. Workflow of the adopted bibliometric method

The specific search query employed is detailed in Table 1. Data preprocessing is conducted to address inconsistencies across different databases, including automated data cleaning, deduplication, and time-slicing options. CiteSpace is utilized for this purpose, providing advanced customization options for standardization. The final dataset of 600 articles serves as the foundation for subsequent bibliometric analysis in the study.

Table 1. Applied Search Query.

Database	Search Query	Result
WoS	((TS=("digital* transform*")) OR TS=(digitalization)) AND TS=("supply chain management") and English (Languages) and Article or Review Article (Document Types)	**325**
Scopus	(TITLE-ABS-KEY ("digital* transform*") OR TITLE-ABS-KEY-AUTH (digitalization)) AND TITLE-ABS-KEY ("supply chain management") AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))	**355**
Pubmed	(("digital transformation"[Title/Abstract]) OR (digitalization [Title/Abstract])) AND ("supply chain management"[Title/Abstract])	**13**

3. Results

3.1. Development stages of DT in SCM

The realm of DT research in SCM has undergone extraordinary expansion over the past two decades. Figure 2 features a red dashed line that best fits the growth trend of cumulative publications. An exponential fit model was found to provide the most accurate representation of this growth, with a Mean Square Error (MSE) of approximately 841.47. According to the exponential best-fit model, the cumulative number of articles is projected to reach approximately 651 by the end of 2023.

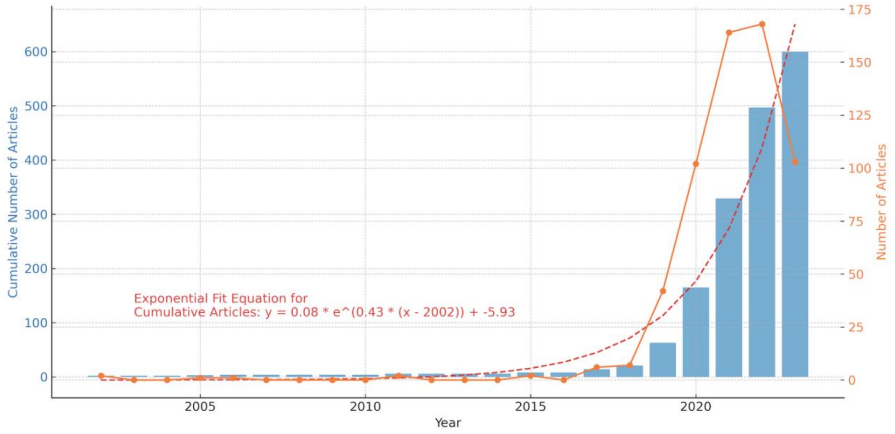

Figure 2. Literature trends of DT-SCM from 2002-2023

The holistic analysis indicates a marked shift occurs from 2017 onwards, with a significant uptick in annual publication volume. Rapid advancements in technologies pertinent to DT—such as the IoT and information technology—have likely been instrumental in fueling this increase in scholarly output. The year 2019 marks a pivotal moment, witnessing an exponential growth in publications. Exponential growth in a field typically signifies the influence of some underlying catalyst. In this context, the COVID-19 pandemic appears to be a plausible driver, as it likely accelerated DT initiatives. The pandemic necessitated shifts to remote work and amplified the importance of online business operations. Consequently, it exerted considerable impact on global supply chains, spurring increased research and practical applications in DT (Khan et al., 2023). Furthermore, since 2019, the rapid popularization of AI and big data technologies has deepened both corporate and academic understanding of DT's significance. This has caused digitalization to evolve from a mere technological trend to a market imperative, giving rise to concepts like agile SCM and digital SCM (Centobelli et al., 2020). In summary, the field of SCM has increasingly focused on leveraging cutting-edge technologies, elevating DT from a peripheral subject to a central area of scholarly and practical focus.

3.2. Keywords mapping

Keywords serve as a succinct summary of a paper's primary focus, making keyword analysis a valuable tool for identifying trending topics within a specific field. Figure 3 displays a keyword co-occurrence map generated by CiteSpace, focusing on DT research in SCM. In this figure, each circular node represents a keyword, with larger nodes denoting higher keyword frequencies. The links between nodes indicate the degree of relational closeness between respective keywords. The network comprises 403 nodes and 1903 edges, representing 403 individual keywords and their co-occurrence relationships. With a network density of 0.0235, the map suggests a relatively close degree of co-occurrence among the keywords. The largest

connected component encompasses 367 nodes, accounting for 91% of the total, indicating a strong core group of interrelated keywords. Flagged nodes, which make up 1.0% of the total, likely represent core concepts, technologies, or methodologies in the field, such as "big data analytics", "sustainable SCM", "performance" and "information technology". "Performance", "impact", and "challenge" have emerged as prominent themes in recent research, while "model" and "logistics" are underrepresented despite their central roles. Keywords like "internet" and "innovation" may represent nascent areas for exploration.

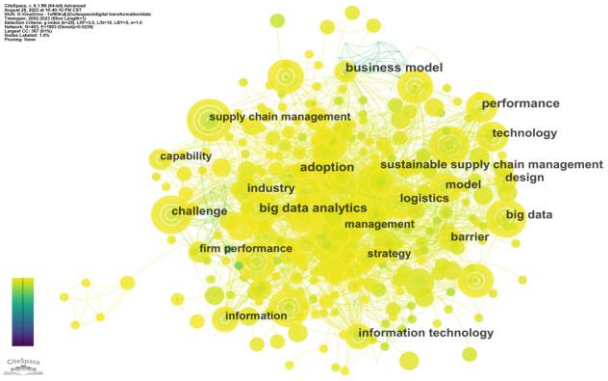

Figure 3. Keywords co-occurrence network of DT-SCM

3.2.1. Keywords Burst

The analysis of keyword bursts highlights evolving foci and thematic trajectories in the realm of DT in SCM. Keywords such as "research agenda" from 2017 to 2020 signify the strategic importance of DT in SCM, reflecting a shift towards applied research aimed at optimizing supply chains. The term "Internet of Things" saw exceptional intensity in 2020, emphasizing its crucial role in shaping contemporary supply chain systems. Emergent keywords like "green" and "sustainability" indicate a growing awareness of environmental stewardship in SCM, suggesting a potential increase in research on the environmental efficacy of DT strategies. Keywords like "model" and "logistics" exhibit high centrality metrics, underscoring their pivotal yet underexplored roles in the academic landscape of the field and warranting further scholarly attention.

3.2.2. Keywords cluster

Figure 4 highlights strong breakout words that have shown marked prominence across the entire dataset, independent of temporal considerations. Due to the abundance of keywords, the Log-Likelihood Ratio (LLR) algorithm was employed to cluster keywords that either have similar meanings or are used to describe comparable concepts. In the domain of DT-SCM, keywords are organized into 10 distinct clusters, as depicted in Figure 5. In this representation, cluster #0 is the largest, followed by cluster #1, and so on. The map reveals that all clusters exhibit a degree

of overlap, suggesting a close interrelationship among them. This is particularly true for the first seven clusters, which are almost entirely overlapping.

Cluster #0 centers on "management efficiency" and the "digital economy"; Cluster #1 deals with "technology adoption and decision"; Cluster #2 focuses on "sustainable supply chain management"; Cluster #3 primarily examines the impact of the "COVID-19 pandemic" on SCM; Cluster #4 emphasizes "bibliometric analysis" in the supply chain; and Cluster #5 pertains to "industry 4.0" and the "global value chains". Among these, Cluster #0 and Cluster #1 are the largest and are primarily concerned with technology adoption and SCM efficiency, marking them as current areas of intense research focus. The highest-quality cluster, Cluster #10, with a Silhouette value of 0.935, underscores that the topic of the "development model" is both highly specific and well-defined. For instance, Cluster #0 clearly underscores the impact of DT on enhancing management efficiency within SCM. Cluster #2 reveals an integration of emerging technologies into SCM practices, starting from around 2018. The year 2020 marked a pivotal moment, as the advent of the COVID-19 pandemic prompted significant shifts in business models and accelerated the reliance on digital means, thereby propelling the DT of supply chains. Within Cluster #5, the entry into the Industry 4.0 era in recent years has had a notable impact on supply chain models.

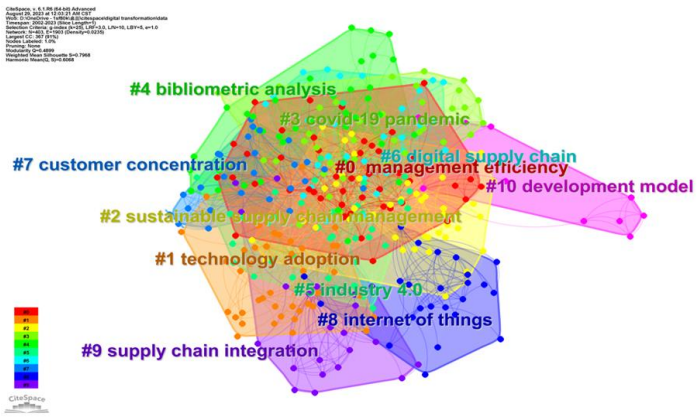

Figure 4. Keywords cluster of DT-SCM

3.3. Keywords evolution analysis

Keyword timezone analysis provides a temporal overview of research evolution in Digital Transformation within Supply Chain Management (DT-SCM). In Figure 5, research on SCM traces back to 2005, with early emphasis on business models. A hiatus in significant activity is observed until 2017 when applied research merges science and technology with SCM, particularly focusing on information technology. By 2019, with the advent of big data and

Industry 4.0, research in DT-SCM experiences an explosive surge, addressing challenges and barriers associated with DT.

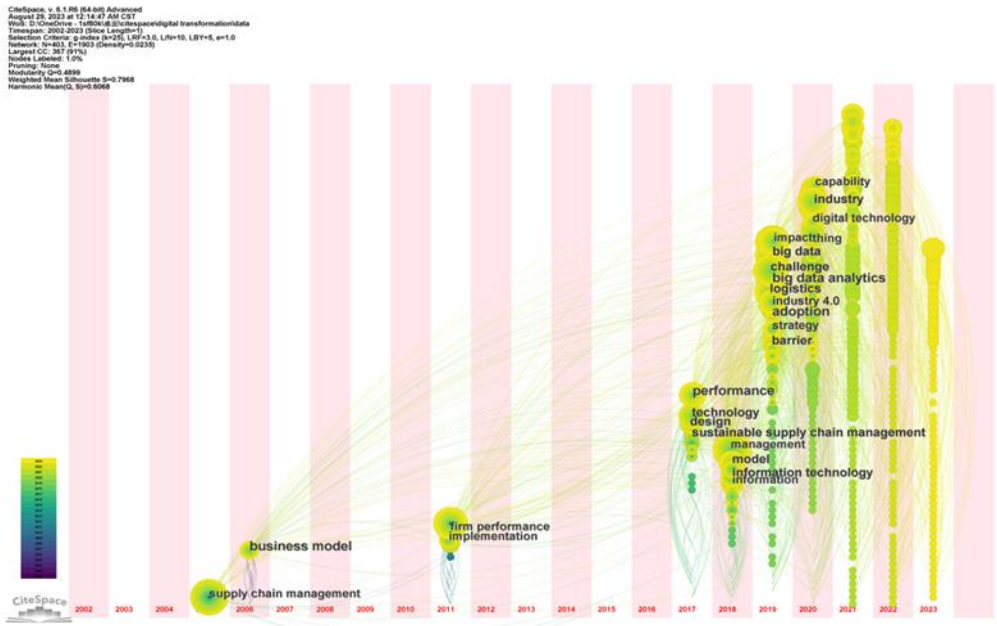

Figure 5. Keyword timezone of DT-SCM

Further examination in Figure 6 reveals intensified cross-linkages among research foci post-2017, emphasizing the need for a holistic evaluation of interplay between thematic clusters. For instance, the relationship between management efficiency and technological adoption signifies the role of innovations in supply chain efficiencies. Similarly, connections between Industry 4.0 and the COVID-19 pandemic highlight the potential applications of technology in emergency response frameworks, emphasizing the need for multifaceted solutions to supply chain challenges.

4. Discussion

This section synthesizes the findings of the scientometric and bibliometric analyses with the literature review, highlighting the rapid ascent of Digital Transformation in Supply Chain Management (DT-SCM) and outlining future research directions.

Determinants of DT in Traditional Supply Chain Structure: Highly cited literature and authors offer insights into influential perspectives, emphasizing that DT extends beyond technology to address global SCM challenges. The surge in publications on DT research within SCM, particularly post-2017, aligns with the advent of Industry 4.0 and the exponential growth of technologies integral to DT.

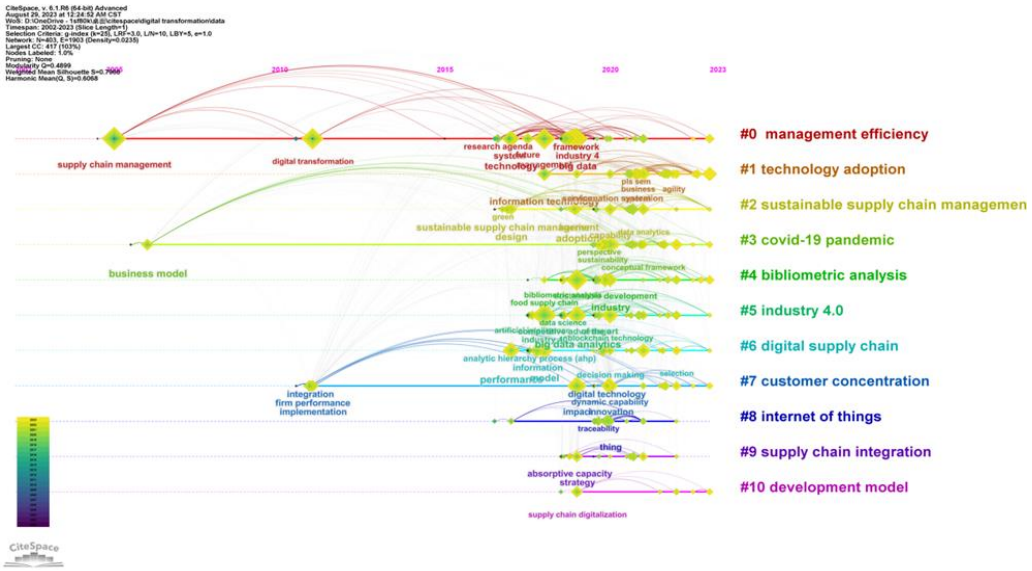

Figure 6. Keywords cluster timeline on DT-SCM

Current Status and Research Focus of DT-SCM: Keyword analysis reveals hotspots and core concepts, with emerging themes like big data analytics and information technology gaining prominence. Sustainable SCM emerges as a critical area of investigation, reflecting a paradigmatic shift towards environmental stewardship in digital SCM. While management efficiency remains a dominant cluster, research increasingly integrates avant-garde technologies like AI and big data.

Future Research Trends and Directions of DT-SCM: The evolution of keywords over time suggests a trajectory towards sustainable SCM and IoT-driven applications. Multidisciplinary research will likely tackle challenges and nuances associated with digital SCM, emphasizing the integration of digital tools and sustainability initiatives. The discussion also underscores the necessity for interdisciplinary collaboration and the exploration of emergent themes.

DT-SCM Evolution Model: The developed framework provides a strategic tool for navigating the complex landscape of DT in SCM. It encompasses the current state of research, research challenges and limitations, future trajectories, determinants of DT-SCM, influential perspectives, and emerging themes. The model underscores the importance of addressing research gaps, leveraging influential perspectives, and considering the broader implications of technological advancements in SCM [Figure 7].

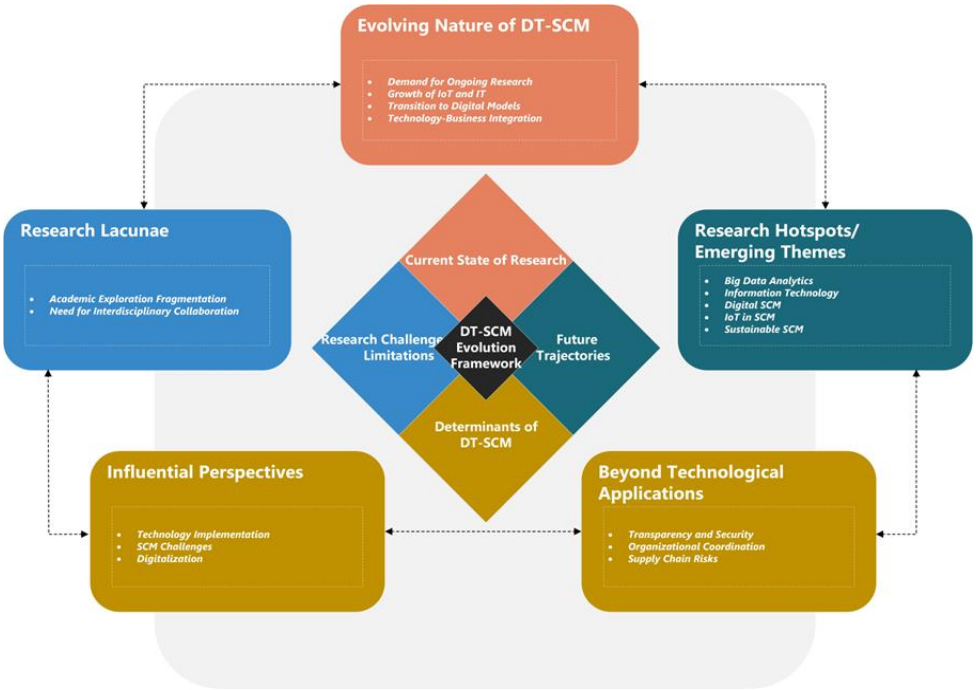

Figure 7. DT-SCM evolution framework

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