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Supply Chain Strategy Trends: Lean, Agile, Leagile

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Abstract

This study analyzes trends and relationships in Lean, agile, and agile supply chain strategies through bibliometric methods and content analysis. Using data from the Scopus database for the period 1996-2023, this study maps the evolution of research with the help of the Biblioshiny and VOSviewer tools. The results of the analysis reveal that publications related to supply chain strategies have shown a consistent increase, especially after 2015, with the highest number in 2023. In terms of contributions, the study identifies the most influential authors, institutions, and keywords in the related literature. Key findings point to a strong interconnection between Lean, agile, and agile strategies, reflecting the broader integration and application of the three strategies in Supply Chain Management research and practice. The study also highlights that recent research tends to focus on how these three strategies can be used synergistically to meet supply chain challenges in an increasingly dynamic and complex business environment. This conclusion offers important insights for academics and practitioners alike, indicating that the incorporation of Lean, agile, and leagile strategies can provide greater flexibility in addressing market demand volatility and supply chain uncertainty. Thus, this research makes a significant contribution to the understanding of the development of supply chain strategies and offers a basis for further study and practical implementation in supply chain management.

Keywords: Agile, Bibliometric Analysis, Leagile, Lean, Supply Chain Management, Supply Chain Strategy.

Introduction

Today, the global business environment recognizes and understands the complexities and dynamics of a rapidly changing world (1). A business environment is defined by the presence of volatility, uncertainty, complexity, and ambiguity (VUCA). Volatility shows dynamics in the form of speed, volume, magnitude, and dynamics of change. Uncertainty indicates that events are unpredictable. Complexity indicates confusing problems. Ambiguity shows the unclear reality and conditions that have various meanings. Enhancing supply chain (SC) performance in the VUCA environment is increasingly prioritized by both the business sector and the academic community (2). The paradigm of Lean and agile strategies in the SC has received attention given the many changes in demand from stakeholders to serve unpredictable markets. The adoption of Lean and Agile SC enhances organizational flexibility, responsiveness, and risk mitigation, enabling effective management of volatility (3).

The theory of Lean Supply Chain Management (LSCM) has garnered interest ever since Lamming (4) initially introduced the term. LSCM facilitates the removal of waste, improvement of quality, reduction of costs, and enhancement of flexibility throughout the supply chain (4–6). LSCM practices have been recognized as effective strategies for enhancing competitiveness, managing environmental uncertainty, and addressing the challenges posed by global climate change, social responsibility, global pandemics like COVID-19, and demand uncertainty (7). Simplifying internal and upstream processes can improve the effectiveness of Lean principles on performance (8). Lean management is a methodical elimination of tasks that do not add value to an organization. When applied across the entire SC, it can enhance corporate performance and the capacity to gain a competitive edge (9). The goal of Lean Supply Chain (LSC) is to meet individual customer needs efficiently and effectively by minimizing costs and waste (10). LSC employs management practices such as Just-in-Time (JIT), Kanban, and Six Sigma, along with manufacturing techniques like tensile flow and setup time reduction (11).

The concept of agile strategy was introduced in the 1990s, nearly two decades ago (12). Agility is described as a paradigm that integrates various organizational elements, including structure,

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logistics, information systems, and overall mindset (13). Viewing agility as a commercial paradigm underscores its critical role in the business world and highlights its contemporary relevance (14). Agility primarily focuses on an organization's ability to thrive and compete in ever-evolving environments. Organizations that adopt agility exhibit a swift and effective capability to respond to shifting demands and environmental changes (15). Agile supply chains (ASC) prioritize the rapidity, adaptability, cost-effectiveness, flexibility, and enhanced production of goods and services (3). Businesses must not only be flexible but also resilient, meaning they go beyond flexibility in responding to unpredictable external threats. This concept has been widely used in various industries but remains somewhat vague (16, 17). It has gained significant attention since the global COVID-19 pandemic (18–22). In the context of manufacturing and service industries, ASC can improve a company's competitive ability in vulnerable environments (23, 24).

Lean and agile are two important strategic approaches, so many companies have implemented both approaches simultaneously, often referred to as hybrid strategies (25–27) or leagile supply chains (28). The leagile approach was first introduced by Lehigh University researchers in the early 1990s and demanded that companies be responsive to changes in consumer demand, both quantity, quality, and product design (29). Leagile is a combined strategy of Lean manufacturing upstream and agile response downstream (30). The primary distinguishing feature of this chain is the decoupling point (DP), which serves as the strategic stockpile within the SC. Efficiency is the primary objective in the upstream part of the DP, whereas responsiveness is the primary objective in the downstream section (31).

Leagile enables organizations to produce products in a standardized format for as long as feasible, and thereafter assemble them upon receiving an order or request from the end customer (32). Companies need to implement leagile SC design because it allows them to remain cost-effective and responsive at the same time to grow according to retail and market demands (33). The leagile model, especially in the service sector, is grounded in specific values and cultural elements (34). The goal is to provide faster and more adaptable responses to evolving customer needs, facilitate more efficient integration of customer feedback, improve team communication, increase productivity, and drive a paradigm shift in thought processes.

The increasing adoption of Lean, agile, and leagile strategies by companies has prompted scholars to conduct an in-depth literature review. In the context of Lean Supply Chain Management (LSCM), a study using bibliographic clutch analysis was conducted to identify important intellectual advances in the most cited literature (11, 35). Their research reveals that this literature focuses on two main areas: Supply Chain aligning Lean and agile principles, and performance evaluation. In addition, they explored critical issues and prospective trends in LSCM during the period 1996–2018 using a longitudinal keyword network analysis. An innovative roadmap model that integrates the concept of Lean and green supply chain in Digital Supply Chain Management has been introduced to achieve sustainable performance (36). In addition, research on the development of information technology (IT) themes in SCM Lean and agile during the period 1996 to 2019 provides important insights into technology trends in SCM (37). A recent literature review in SCM agile, which uses systematic network analysis, also shows the dynamics and application of agile strategies in supply chains (38).

Previous literature studies mostly analyzed solely Lean and Agile. This study further analyzes Lean, agile, and leagile supply chain strategies using bibliometric analysis. The study includes leagile analysis because many businesses are implementing Lean, and agility approaches simultaneously in response to an increasing VUCA environment.

This research presents a novel and contemporary perspective on the evolution of Lean, agile, and leagile SCM, surpassing prior studies conducted between 1996 and 2018 (35) as well as covering the period from 1996 to 2019 (37). Notably, our investigation extends the timeframe to 2023, providing a more comprehensive and up-to-date analysis of this crucial subject.

To better understand the evolution and impact of these strategies in SCM, this research seeks to answer the following key questions:

RQ1: What are the research trends related to Lean, Agile, and Leagile strategies in Supply Chain Management from 1996 to 2023?
RQ2: Is there any interrelation or dependency between the implementation of Lean, Agile, and Leagile strategies in supply chains operating in VUCA environments?
RQ3: What are the most prominent topics in research on Lean, Agile, and Leagile SCM based on bibliometric analysis?
RQ4: What are the emerging areas and potential gaps in Lean, Agile, and Leagile Supply Chain Management research that future studies should explore?
The purpose of this paper is to investigate research trends where Lean, agile, and leagile paradigms coexist in the realm of SC. In this study, a bibliometric analysis, mainly focusing on the Scopus database, was conducted to check whether there is any interdependence between the mentioned approaches and to identify the most prominent topics related to these studies as well as research trends in this area.
This paper begins with an introduction to the topic of synergy and literature related to Lean, Agile, and Leagile management approaches. The research methodology section describes the data collection steps and bibliometric analysis process. This is followed by the presentation and discussion of the main results. The paper concludes by proposing the need to utilize Lean, agile, and leagile approaches to optimize organizational management.

Methodology

The methodology outlined in this study presents a hybrid narrative approach to conducting systematic reviews of research papers within the realm of strategic supply chains, which include Lean, agile, and leagile strategies. This approach combines elements of structured review, bibliometric analysis with the help Biblioshiny App, and narrative review to explore topics holistically (39). Bibliometric analysis using Biblioshiny has advantages because it will produce some information. Information obtained from Bibliometric analysis using Biblioshiny is in the form of a) The trend of citations over time for the number of papers published on Lean Supply Chain. b) The concepts of Agile Supply Chain and Leagile Supply Chain. c) List of the top 10 research publications. d) The three-field plot consists of three sections: the left field represents the sources of publication, the middle field represents the author, and the last field represents the keywords. e) Examining Author Productivity Using Lotka's Law; f) Visualizing Author Productivity Using Lotka's Law; g) The top 20 keywords used in the author's keyword section of the papers; h) A word cloud representing the author's keywords; i) Most Relevant Affiliations; j). Country's Production of Research Articles; k) Clusters of high-frequency keywords in the studies on Lean, agile, and Lean in supply chain; l) Overlay Visualization of Supply Chain Strategy (Lean, Agile, Leagile); and m) Co-Citation Network of the Authors in the Collected Sample.
The initial step in conducting a bibliometric analysis involves selecting appropriate data sources that align with the objectives of the study. While there are a large number of bibliographic databases available, there are five main databases commonly used in bibliometric analysis: Web of Science (WoS), Scopus, Google Scholar (GS), Microsoft Academic (MA), and Dimensions (40). For this particular study, Scopus was chosen as the primary research database due to its extensive collection of documents. In addition, Scopus offers a variety of data export formats (BibTeX, RIS, and CSV), which are compatible with various tools used for bibliometric science mapping analysis (37, 40, 41). Scopus also offers a wide coverage of relevant journals related to Supply Chain Management topics, which ensures that the research is based on extensive and representative data. In this study, we examine the yearly evolution of citations, paper counts related to Lean, Agile, and Leagile Supply Chains, research publications, author productivity, keyword analysis, affiliation and country analysis, thematic research areas, the temporal scope, and co-citation analysis.
The search was conducted on December 25, 2023, and focused on the following keywords: "Lean Supply Chain," "Agile Supply Chain," and "Leagile Supply Chain," applied to document titles, abstracts, and keywords. The search results included publications from 1996 to 2023, as Scopus only returned articles within this range. We further refined the search by applying filters: a) publications not in English were excluded, b) documents not categorized as "Articles" were removed, and c) only publications from peer-reviewed journals were included.

The resulting collection consists of 497 publications, which we export in BibTeX and CSV formats for subsequent analysis using two widely recognized and effective bibliometric analysis tools, biblioshiny (42) and VOSviewer (43). This study followed a structured approach in compiling a bibliometric analysis, as shown in Figure 1.

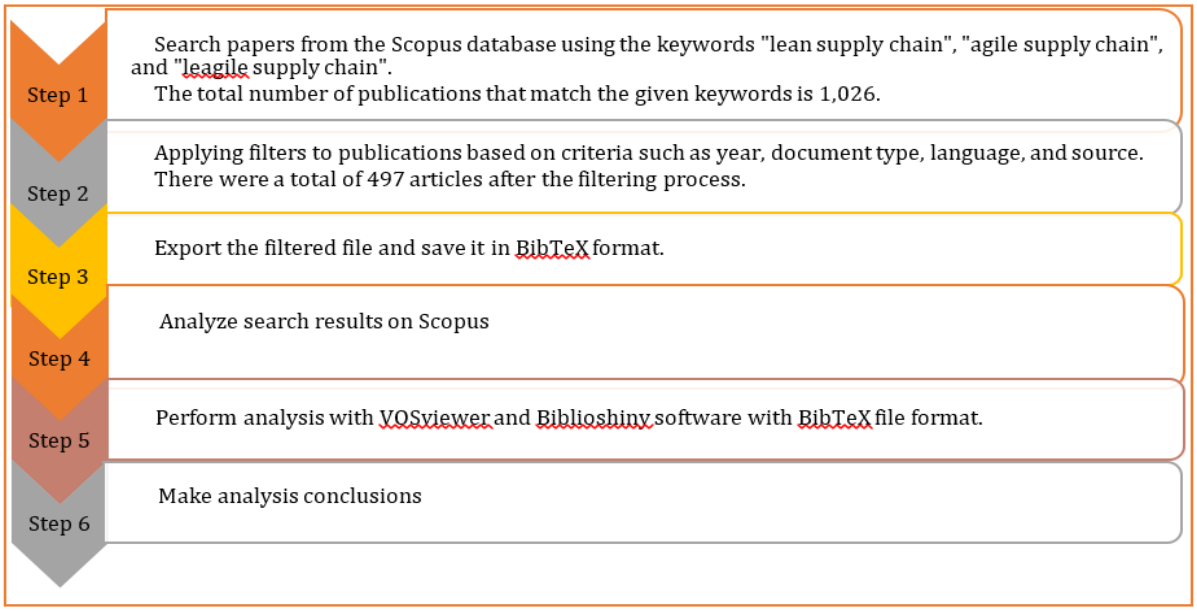

Figure 1: Research Methods

Results

Bibliometric analysis is a research methodology that combines statistical and quantitative techniques to reveal underlying patterns in scientific publications. This is extremely important when it comes to mapping science, particularly when empirical contributions lead to a broad, fragmented, and contentious study field (42). Following that, the study used biblioshiny, a web-based interface for bibliometrix, to produce a three-field plot and visually represent author productivity using Lotka's law. Furthermore, word clouds are generated to represent the most commonly utilized terms and monitor the output of authors over a period utilizing the biblioshiny application. Important information about database collections can be found in Table 1.

Based on Figure 2, which illustrates the yearly citation trend from before 1999 to 2023, there is a clear and steady increase in the number of citations related to Lean, agile, and leagile supply chain strategies. In the early years, citations were minimal, indicating that research on these topics was still developing. However, from 2004 onwards, there is a noticeable rise in interest, with a more significant surge after 2012. By 2023, citations peaked at 2,800, reflecting the growing academic and industrial focus on these strategies, especially in response to global supply chain disruptions, such as the COVID-19 pandemic. This figure underscores how critical these strategies have become in addressing the challenges of modern supply chain management, emphasizing the importance of flexibility, efficiency, and resilience (44, 45).

Table 1: Main Information Regarding the Collection

Description	Results	Description	Results
Timespan	1996:2023	Author's Keywords (DE)	1282
Sources (Journals)	242	Authors	1147
Documents	497	Authors of single-authored docs	50
Annual Growth Rate %	15.23	Single-authored docs	55
Document Average Age	7.2	Co-Authors for Doc	2.94
Average citations per doc	36.84	International co-authorships %	24.9
References	1	article	493
Keywords Plus (ID)	1415	article article	5

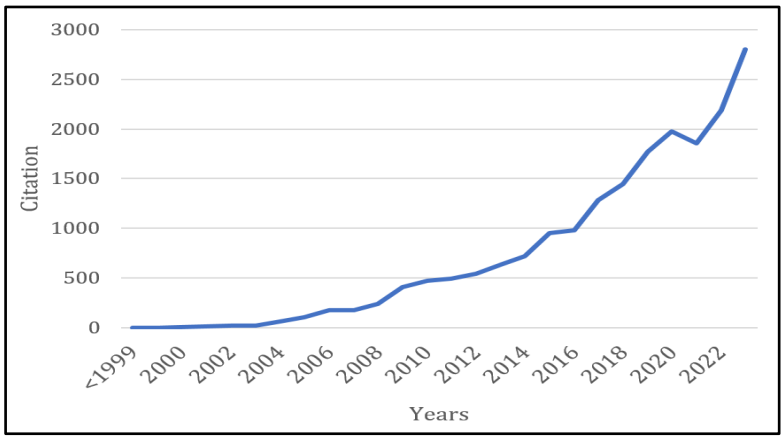

Figure 2: Evolution of the Citations per Year

Among the 497 selected papers, the earliest in the dataset dates back to 1996, showing that research on LSC, ASC, and leagile SC predates this year. As illustrated in Figure 3, the concepts of LSC, ASC, and leagile SC have demonstrated a consistent upward trajectory since 1996, peaking in 2023. The results of the bibliometric analysis show that publications related to lean supply chains have grown steadily since 1996, especially in the manufacturing sector, with a peak before 2015. Publications on agile supply chains driven by the need for flexibility in the technology sector. Leagile supply chain saw a surge in publications especially post-COVID-19, due to the increasing need to combine efficiency and flexibility. All three strategies reached the peak of the number of publications in 2023, with leagile showing the fastest growth in recent years.

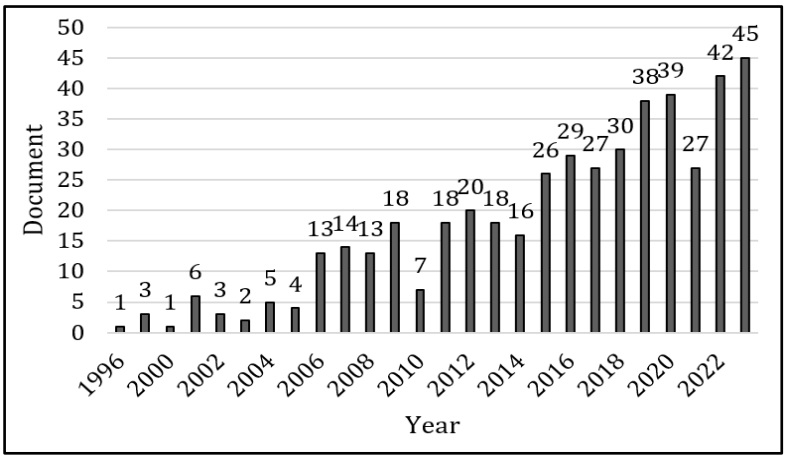

Figure 3: Number of Papers Published on LSC, ASC, Leagile SC

The bibliometric analysis of supply chain strategies, as shown in Table 2, highlights the leading contributors to Lean, agile, and leagile supply chain research from 1996 to 2023. Moyano-Fuentes J with 12 articles, is recognized for his significant work on Lean supply chains, particularly integrating Lean principles into manufacturing, with his highly cited paper "Lean Management, Supply Chain Management, and Sustainability: A literature review" (434 citations). Datta S and Mahapatra SS each with 9 articles, have made substantial contributions to agile supply chain management, focusing on decision-making in dynamic environments, with Datta's key article on supplier selection earning 39 citations. Tortorella Gl also with 9 articles, is known for advancing research on leagile supply chains, where his work on Lean practices has garnered 128 citations. Additionally, Christopher M with 6 articles, has made a foundational impact with his article "The Agile Supply Chain: Competing in Volatile Markets" (1,432 citations), which remains influential in understanding supply chain flexibility in volatile markets. These authors have significantly shaped the field through their impactful research, guiding both academic and practical developments in modern supply chain management.

Table 2: Most Relevant Authors

Authors	Articles	Articles Fractionalized
Moyano-Fuentes J	12	3.70
Datta S	9	2.67
Mahapatra SS	9	2.67
Tortorella Gl	9	2.27
Barnes D	8	3.50
Wu C	8	3.50
Maqueira-Marín JM	7	2.03
Agarwal A	6	2.00
Christopher M	6	3.00
Sahu AK	6	1.83

Figure 4 provides information on the top 10 research publications that have contributed articles on this subject. These sources have collectively produced 129 articles, which accounts for 26% of all publications in this field. Notably, the 'International Journal of Supply Chain Management' stands out as the leading publisher of papers in this field, followed by the 'International Journal of Production Economics,' 'International Journal of Services and Operations Management,' 'International Journal of Agile Systems and Management,' and 'International Journal of Production Research'.

Sankey diagrams or three-plane plots are utilized to show elaborate flow scenarios (46). The three-field plot specifically tracks the flow of information across three categories: publication source (left field), author (middle field), and keywords (right field). To improve clarity, only the top 10 items in each category are considered for analysis. Figure 5 indicates that the majority of publications focus on 'Agile supply chains,' and these articles are mostly published in the journal 'Production Planning and Control'. Notably, Moyano-Fuentes J emerged as the most prolific writer in this field. 'Lean supply chains' represent the second most prominent area of study, followed by research focusing on 'Lean,' which shows a considerable volume of research papers in this domain.

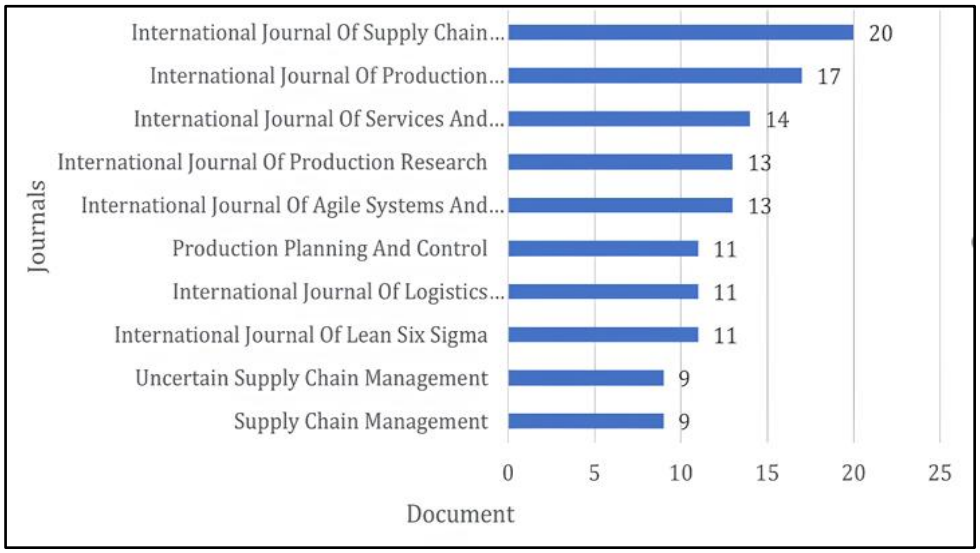

Figure 4: Top 10 Research Publications

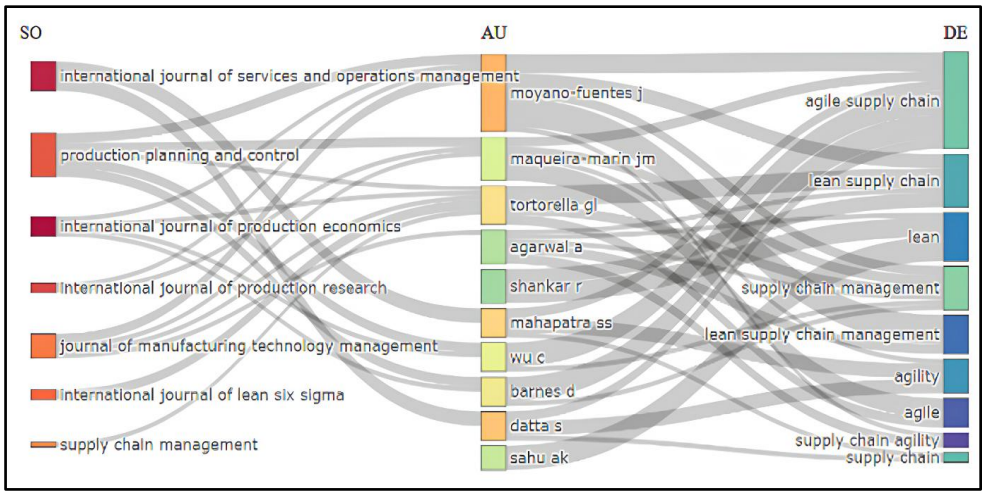

Figure 5: Three-field Plot (Left Field: Sources of Publication, Middle Field: Author, Last Field: Keywords)

Influence of Author

Lotka's Law states that the frequency distribution of authors who have published a certain number of articles can be used to predict the number of authors who have written a different number of articles. Lotka's Law of Scientific Productivity states that 84.4% of the authors in the chosen field will only create a single article. Based on the data presented in Table 3 and Figure 6, it can be inferred that only 15.6% of individuals have written more than one article. Additionally, it is interesting that one author has produced a maximum of 11 publications.

Table 3: Author Productivity through Lotka's Law

Documents written	No. of Authors	Percentage of Authors	Documents written	No. of Authors	Percentage of Authors
1	968	0.844	6	2	0.002
2	115	0.1	7	2	0.002
3	36	0.031	8	2	0.002
4	11	0.01	9	3	0.003
5	7	0.006	11	1	0.001

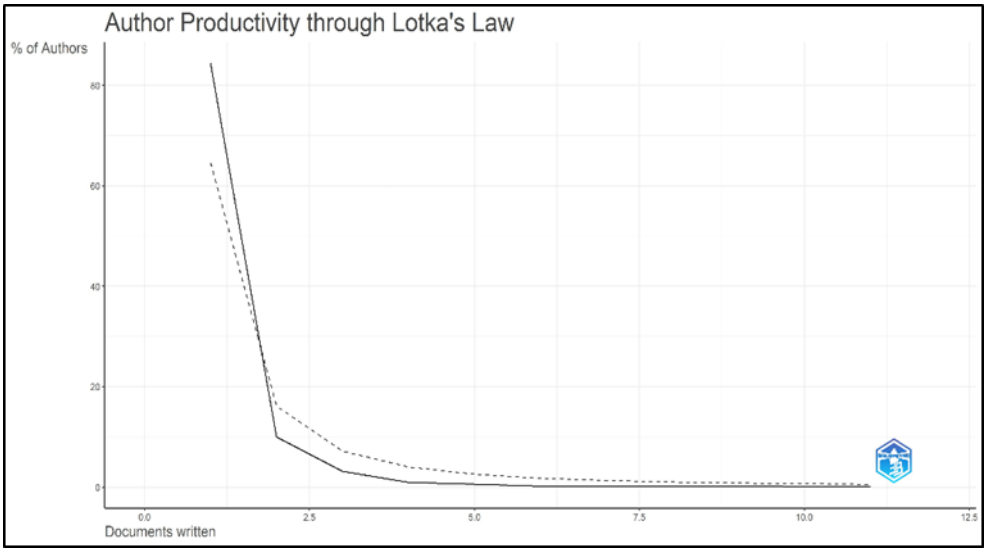

Figure 6: Graphical Representation

Keyword Analysis

Keyword analysis can be used to determine the most commonly utilized words in the document by the author, referred to as the Author keyword. Keyword analysis is utilized to find the most often used words by authors in the title of the publication known as Keyword Plus. The author utilized a total of 1282 keywords in the title of the referenced publication. Figure 7 illustrates the distribution of the top 20 keywords used in the author's keywords of the analyzed papers, revealing significant trends in SC strategy research. The most frequent keywords are "supply chain management" with 96 occurrences, followed by "supply chain" (68 occurrences), "agile supply chain" (66 occurrences), and "Lean supply chain" (54 occurrences), highlighting a predominant focus on management, agility, and efficiency in SC. Other notable keywords, such as "agility," "Lean," and "sustainability," reflect a strong emphasis on flexibility and sustainability within the context of SC. These trends indicate that strategic approaches like Lean, agile, and leagile are becoming increasingly crucial for enhancing responsiveness and operational efficiency, pointing to relevant research directions for addressing modern challenges and dynamics in SCM. Figure 8 displays the word cloud representing the keywords utilized by the author.

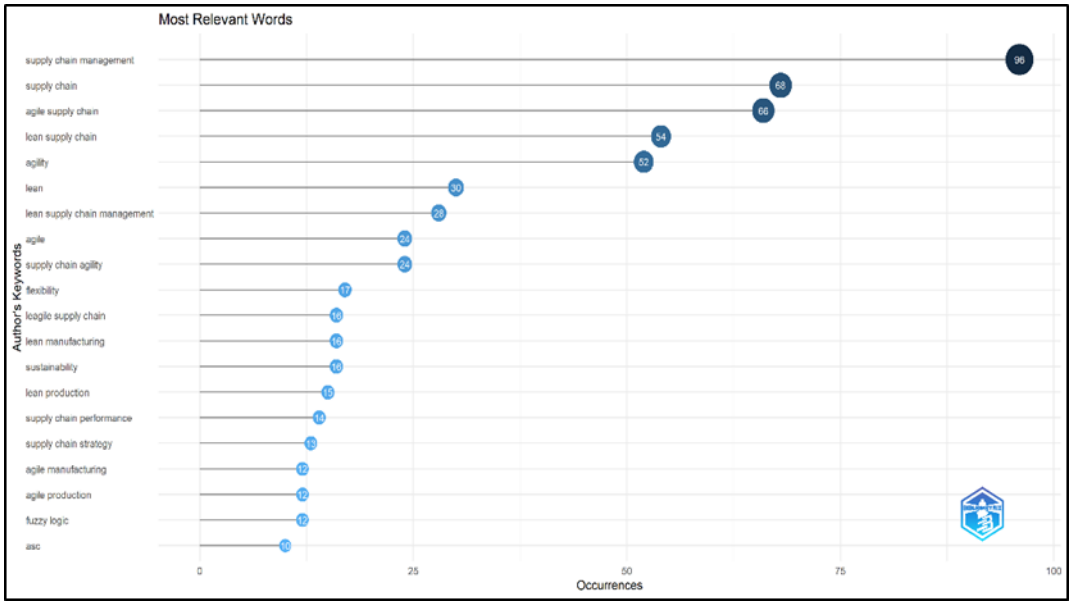

Figure 7: Top 20 Keywords used in the Author's Keywords of the Papers

Figure 8: Word Cloud of Author's Keywords

Affiliation Analysis

Figure 9 shows the most relevant affiliations in research on supply chain strategy trends: Lean, Agile, and Leagile, based on data from Scopus. Universidad de Jaén and the University of Tehran lead with 13 publications each, followed by Universidade Federal de Santa Catarina with 12 publications. Cranfield School of Management, Indian Institute of Technology Delhi, Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa, National Institute of Technology Rourkela, and Birla Institute of Technology and Science each contributed 10 publications, while Cranfield University and Universiti Teknologi Malaysia complete the list with 9 and 8 publications, respectively. This data indicates that research on supply chain strategies incorporating Lean, Agile, and Leagile approaches is dominated by contributions from various educational and research institutions worldwide. The geographical diversity of these affiliations reflects the global relevance of research on supply chain strategies, focusing on both theoretical development and practical application across different industrial sectors, enhancing the efficiency and effectiveness of supply chains in various industries.

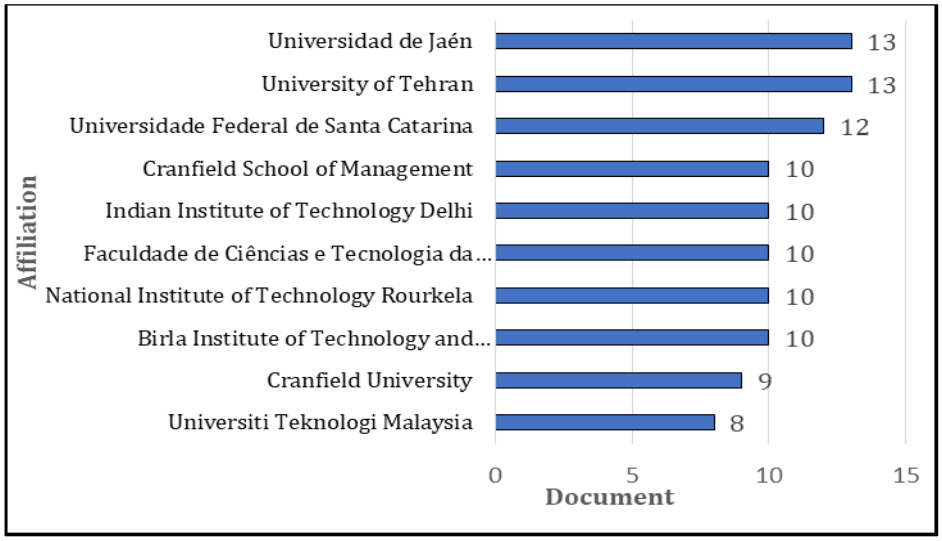

Figure 9: Most Relevant Affiliations

Country Analysis

Table 4 highlights the top 10 countries contributing the highest number of articles on Lean, agile, and leagile supply chain strategies in the manufacturing and service industries. India ranks first with 91 articles, followed by the United States with 70 publications, indicating a growing research focus on these supply chain strategies in both countries. Figure 10 visually represents the geographical distribution of research contributions, with different shades of blue indicating the number of articles published by each country. Darker shades of blue represent countries with higher publication counts, such as India and the United States, while lighter shades indicate countries with fewer contributions. Gray areas represent countries that have not yet engaged in research on these supply chain strategies. The map illustrates that while significant research is concentrated in certain regions, many countries have yet to contribute to studies on Lean, agile, and leagile supply chain strategies, pointing to opportunities for broader global engagement in this field.

Table 4: Top 10 Countries Contributing to Articles on the Agile Supply Chain in the Manufacturing and Service Industry

Country	Documents	Country	Documents
India	91	Malaysia	28
United States	70	Spain	24
United Kingdom	63	Indonesia	20
Iran	48	Australia	16
China	44	Brazil	14

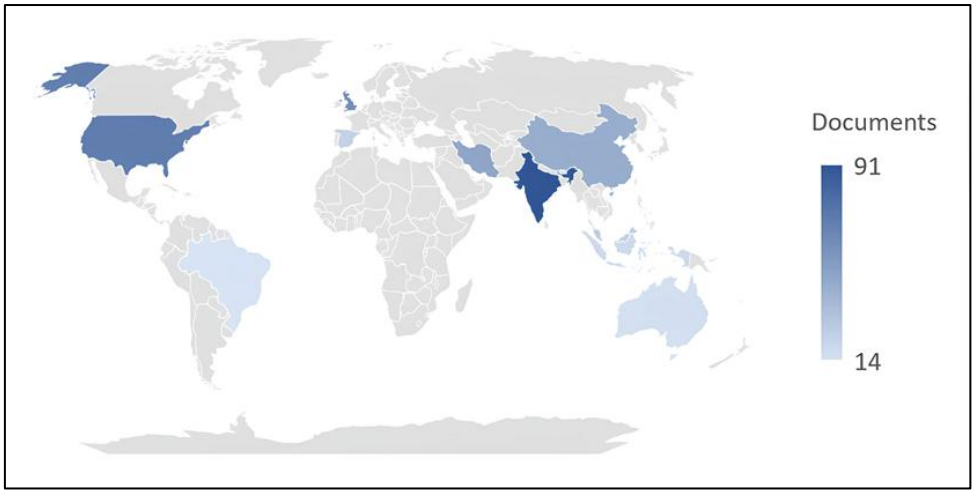

Figure 10: Country's Production of Research Articles

Thematic Research Areas on Lean, Agile, and Leagile Supply Chain

We have counted five clusters aligned with high-frequency keyword co-emergence analysis related to research on Lean, agile, and agile SC. The cluster networks given in Figure 11 are roughly displayed according to their ratings to show the acquired nodes. Thus, the cluster is labeled with the following five thematic research areas: The central yellow cluster highlights "supply chain management," and includes terms such as "information management," "knowledge management," and "decision support systems," emphasizing strategic and informational aspects. The red cluster focuses on "Lean supply chain" and related terms like "Lean manufacturing," "Lean production," "supply chain strategy," "operational performance," "efficiency," and "industry 4.0," emphasizing efficiency and waste reduction. The blue cluster centers on "agile supply chain," and includes terms like "agile manufacturing systems," "flexibility," "supplier selection," "manufacture," and "customer satisfaction," highlighting adaptability and responsiveness. The green cluster underscores sustainability, featuring terms like "sustainability," "sustainable development," "risk management," "uncertainty," and "optimization." The purple cluster addresses industry-specific dynamics and competitive advantage, with terms like "automotive industry," "competition," "competitive advantage," "profitability," and "decision support systems." The blue-green cluster emphasizes customer satisfaction and supplier optimization, including terms such as "customer satisfaction," "supplier selection," "manufacture," and "fuzzy logic." These clusters collectively reflect the multifaceted nature of supply chain research, integrating efficiency, adaptability, sustainability, and competitive strategies.

Overlay Visualization of Supply Chain Strategy (Lean, Agile, Leagile)

Figure 12 provides an overlay visualization of supply chain strategy keywords (Lean, Agile, Leagile) using VOSviewer, highlighting the temporal evolution and interconnections of these terms from 2010 to 2020. The central term "supply chain management" dominates the network, indicating its pivotal role in the field. Surrounding clusters reveal distinct themes: recent focus on integrating advanced technologies for efficiency and performance ("operational performance," "industry 4.0"); emphasis on waste reduction and efficiency ("Lean supply chain," "Lean manufacturing"); adaptability and responsiveness in supply chains ("agile supply chain," "flexibility"); growing interest in sustainability and risk management ("sustainability," "risk management"); and strategic and competitive aspects ("information management," "competitive advantage"). Additionally, terms like "customer satisfaction," "manufacture," and "optimization" suggest a diverse range of focus areas, reflecting the dynamic and multifaceted nature of supply chain strategy research over the past decade, encompassing technology integration, efficiency enhancement, adaptability, sustainability, and strategic competitiveness.

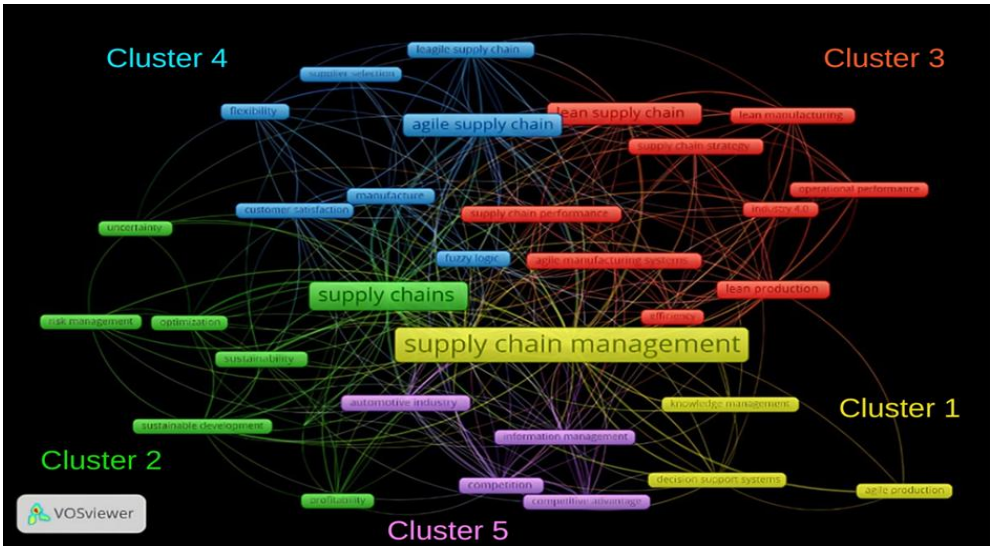

Figure 11: Clusters of High-Frequency Keywords in the Studies on Lean, Agile, Leagile in Supply Chain

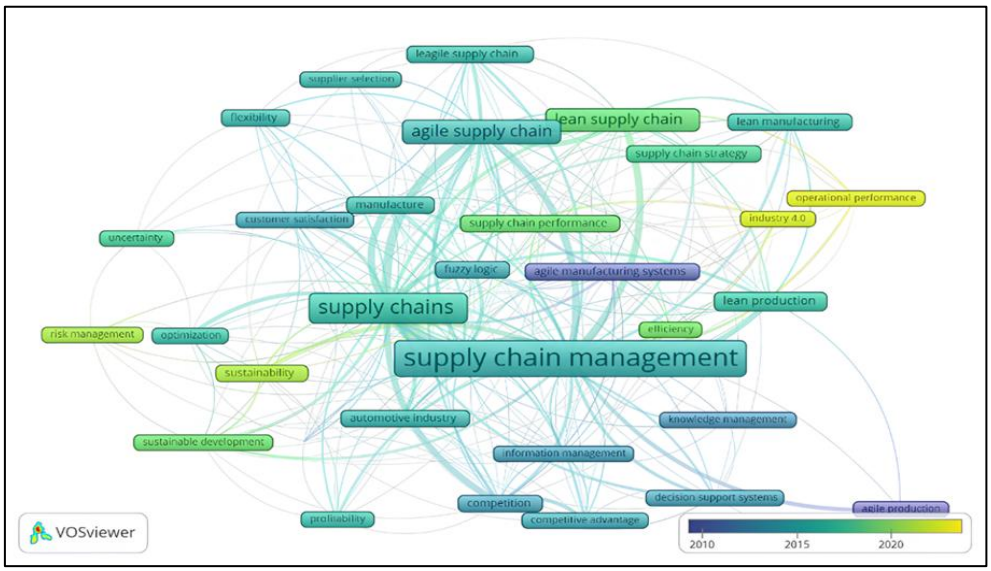

Figure 12: Overlay Visualization of Supply Chain Strategy (Lean, Agile, Leagile)

Co-Citation Analysis

Figure 13 and Table 4 provide an overview of the co-citation network of authors in the collected sample, along with a list of the top ten authors with the maximum citations and link strength. Co-citation analysis is a technique used to identify similarities in the topics discussed in two papers, where papers that share citations are included in the reference lists of other papers. The analytical method selected for constructing this network diagram is 'co-citation' and the unit of analysis is the 'cited author'. Authors with a minimum of 100 citations are eligible for citation analysis. Out of a total of 26,013 authors, only 30 authors were selected for analysis as they met the required threshold. VOSviewer illustrates the overall citation strength of the 30 selected authors, as well as their collaborations with other authors. The author with the highest cumulative link strength is identified.

Table 5 lists the authors with the most citations and total link strength, indicating the level of interconnectedness between authors. Figure 13 depicts a co-citation network featuring 30 authors categorized into four distinct groups. The author with the highest number of citations is Christopher M with 618 citations and a total link strength of 4372, followed by Gunasekaran A with 501 citations and a total link strength of 3592. Other notable authors include Kodali R, Moyano-Fuentes J, Naim MM, Sarkis J, Shankar R, Towill D, Towill DR, and Yusuf YY, each with significant citation counts and link strengths, demonstrating their contributions to the research on this topic.

Table 5: Top Ten Authors with the Maximum Citations and Link Strength

No.	Author	Citations	Total Link Strength
1	Christopher M	618	4372
2	Gunasekaran A	501	3592
3	Kodali R	192	1058
4	Moyano-Fuentes J	172	942
5	Naim M.M	153	1309
6	Sarkis J	149	908
7	Shankar R	219	1871
8	Towill D	165	1414
9	Towill DR	306	2709
10	Yusuf YY	172	1649

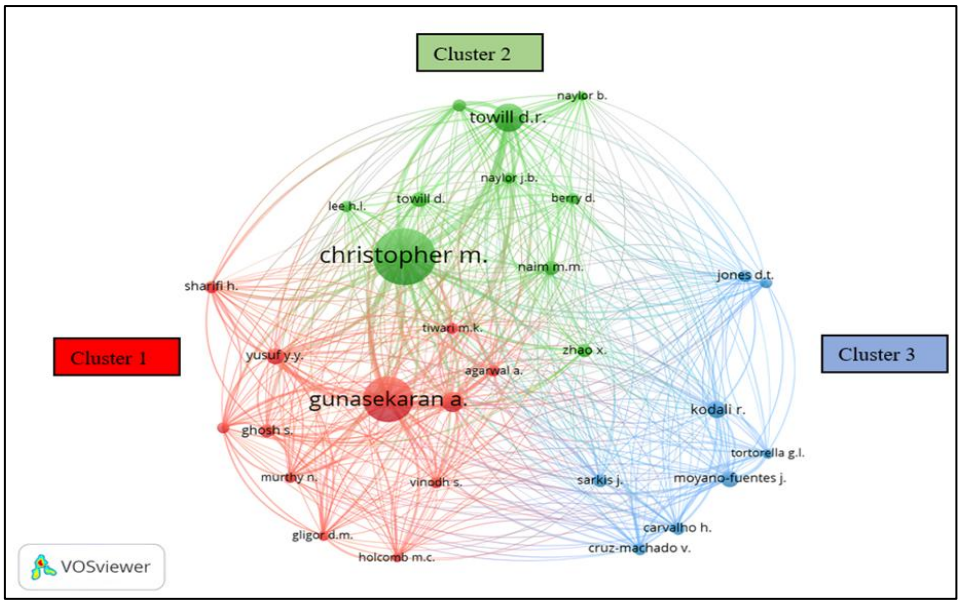

Table 13: Co-Citation Network of the Authors in the Collected Sample

Discussion

The findings from the bibliometric and content analyses shed light on the evolving landscape of SC strategies, particularly in the realms of Lean, agile, and leagile approaches. These strategies have garnered significant attention in the academic and industrial sectors due to their potential to enhance operational efficiency and responsiveness to dynamic market demands. The global business environment continues to evolve and understanding how these strategies are applied across different regions and industries is crucial for optimizing supply chain management. One of the key insights derived from the analyses is the increasing convergence of lean and agile principles in SCM. The literature often revolves around the integration of lean and agile strategies to achieve a balance between cost efficiency and flexibility (38). This trend underscores the importance of adopting a hybrid approach that combines the strengths of both paradigms to address the complexities of modern SC. However, the adoption of these strategies is not uniform across regions, and understanding the geographical context helps explain variations in how these approaches are applied.

Furthermore, the analysis of publication trends over time reveals important insights into the evolution of research interest in lean, agile, and leagile strategies. The country analysis of the publication trends on supply chain strategies shows that India and the United States are the most productive countries, with 91 and 70 articles, respectively, on lean, agile, and leagile supply chains. This high output can be linked to the growing research focus in these regions. For instance, India's prominence driven by its large manufacturing sector and the increasing push for efficiency in its supply chains (47), particularly in response to global competition and sustainability

goals (48). Similarly, the United States has a robust technological sector that drives agile supply chain innovations (14), emphasizing adaptability and flexibility. These trends align with the historical growth of lean strategies in manufacturing-heavy economies like Japan in the 1990s (49–51), and the subsequent rise in agile strategies in technology-driven Western economies in agile supply chain strategies reflects a shift toward flexibility and responsiveness (52, 53), particularly relevant to fast-changing technological environments in countries like the U.S. The increasing complexity and volatility of global supply chains further emphasize the need for hybrid strategies such as leagile, especially in highly competitive markets.

Leagile, as a hybrid approach that combines the efficiency of Lean with the flexibility of agile, began gaining traction after 2015. The rise in interest in leagile strategies correlates with the increasing complexity and volatility of global supply chains (28, 54, 55), especially following major disruptions such as the COVID-19 pandemic. In 2023, the volume of publications related to leagile strategies showed a significant surge, surpassing previous records and highlighting the increasing relevance of this approach in managing modern supply chain challenges. This comparative evaluation of publication trends shows that while lean strategies have a historical advantage in terms of volume of research, agile and leagile strategies have demonstrated rapid growth in recent years, driven by the need for greater flexibility and resilience in an unpredictable business environment. The ability to balance operational efficiency with responsiveness is becoming more critical, and this is reflected in the rising academic interest in agile and leagile approaches.

Beyond regional variations, technological advancements are also transforming supply chain strategies. The growing significance of information technology (IT) in lean and agile SC domains is an emerging trend (37, 56). The integration of digital technologies, often referred to as Industry 4.0, has further enhanced the ability of supply chains to be both lean and agile. However, the rise of digital supply chains marks an even more significant transformation. Digital supply chains incorporate technologies such as Internet of Things (IoT), artificial intelligence (AI), and blockchain to increase transparency, data-driven decision-making, and real-time responsiveness throughout the entire supply chain process (57). These technologies allow companies to optimize efficiency and flexibility, aligning well with both lean and agile principles by improving both operational precision and adaptability. The combination of digital technologies with lean and agile strategies enhances supply chain performance, particularly in rapidly changing environments where demand fluctuations and supply chain disruptions are common. By integrating digital supply chains, companies can build more resilient, efficient, and flexible operations. This synergy between digitalization and traditional supply chain strategies will likely shape future developments in SCM as businesses strive for greater competitiveness in an increasingly complex global marketplace. Furthermore, the keyword analysis conducted in this study reveals the consistent use of terms such as 'agile' and 'Lean' in the literature, indicating the enduring relevance of these concepts in SCM. The consistent utilization of these keywords underscores the importance of maintaining lean and agile principles across various phases of the SC to achieve operational excellence and competitive advantage. These strategies, when combined with advanced technologies, offer a powerful framework for modern supply chains to navigate increasing complexity and uncertainty.

Another critical aspect influencing modern SC strategies is the growing emphasis on sustainability. Sustainability has become a key priority for companies worldwide and aligning environmental goals with operational strategies is crucial for long-term success. Integrating lean, agile, and leagile approaches with sustainability objectives allows supply chains to not only optimize for efficiency and flexibility but also to contribute to broader environmental and social goals (58). Future research could delve into how these strategies can support sustainable supply chain practices, particularly in the context of global initiatives to reduce carbon footprints and improve resource efficiency.

Conclusion

This study highlights the significant growth in research on Lean, agile, and leagile supply chain strategies, particularly after 2015, peaking in 2023. By analyzing trends through bibliometric methods, we identified key themes, influential authors, and the increasing integration of these

strategies in supply chain management. The findings suggest that combining Lean, agile, and leagile strategies enhances supply chain flexibility and performance, making them vital in addressing modern supply chain challenges. This study provides a foundation for further research and practical application, particularly in the context of Industry 4.0 and sustainability goals. The research offers valuable insights for academics and practitioners, emphasizing the importance of these strategies in navigating the complexities of today's supply chains.

Limitations and Scope for Further Research

The suggestions for expanding the scope of future research are valuable and could lead to a deeper understanding of supply chain strategies. One key limitation of this study is its reliance solely on Scopus as a database. While Scopus provides a comprehensive and well-curated dataset, it does not cover all available literature. Future studies could address this limitation by utilizing additional databases such as Web of Science, Google Scholar, ResearchGate, and EBSCO, which offer a broader scope of articles. Incorporating these platforms would allow for a more diverse dataset, thereby providing richer insights into supply chain strategy research. Another limitation lies in the scope of the bibliometric analysis, which focuses on quantitative metrics like citation counts and publication frequency. While useful for identifying trends, this approach does not explore the content of individual articles in depth. As a result, it lacks the ability to capture the qualitative aspects and innovations present in the literature. Future research could build on this by conducting more detailed content analyses of the collected articles, which would provide a more comprehensive understanding of the underlying contributions to the field of supply chain management.

Additionally, the integration of Industry 4.0 technologies such as IoT, blockchain, and AI with supply chain strategies like Lean, agile, and leagile is a critical area for future exploration. As these technologies become more prevalent in supply chain operations, understanding how they interact with existing strategies will be essential for improving both efficiency and flexibility. This intersection represents an exciting avenue for future research, particularly in identifying how digital transformation can enhance supply chain resilience.

Moreover, the growing focus on sustainability in Supply Chain Management presents another key area for future research. Future studies could examine how Lean, agile, and leagile strategies contribute to achieving sustainability goals, particularly in terms of reducing environmental impact and promoting long-term resource efficiency. Investigating this alignment between strategy and sustainability could provide crucial insights for businesses aiming to balance profitability with environmental responsibility.

Lastly, future research could focus on industry-specific challenges by examining how these supply chain strategies are adapted to the unique demands of sectors like manufacturing, services, or healthcare. A more targeted approach might reveal distinct patterns in the adoption and success of Lean, agile, and leagile strategies within these contexts.

To guide future research on Lean, Agile, and Leagile strategies in Supply Chain Management (SCM), several key research streams and questions have been identified. These research streams highlight potential areas for further exploration, addressing emerging technologies, sustainability, industry-specific challenges, risk management, and cultural influences. The following table 6 presents the recommended future research questions across different research streams:

Table 6: Future Research Questions

Research Streams	Future Research Questions
Emerging Technologies in SCM	How can emerging technologies (such as AI, blockchain, and IoT) further enhance the synergy between Lean, Agile, and Leagile strategies in Supply Chain Management?
Sustainability in Supply Chains	What is the impact of sustainability initiatives on the integration of Lean, Agile, and Leagile strategies in global supply chains?
Industry-Specific Adaptation	How do specific industries (e.g., healthcare, retail, automotive) adopt Lean, Agile, and Leagile supply chain strategies to address their unique challenges?

Abbreviations

ASC: Agile Supply Chain, CSV: Comma-Separated Values, DP: Decoupling Point, IT: Information Technology, JIT: Just-in-Time, LSC: Lean Supply Chain, LSCM: Lean Supply Chain Management, LASC: Leagile Supply Chain, SC: Supply Chain, SCM: Supply Chain Management, VUCA: Volatility Uncertainty Complexity Ambiguity.

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Author Contributions

Riska wrote the manuscript and provided data and Munjiati Munawaroh analyzed the data. All authors reviewed the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

Ethics Approval

There are no living subjects in this research, and informed consent is not applicable.

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References

1. Ahmed J, Mrugalska B, Akkaya B. Agile management and VUCA 2.0 (VUCA-RR) during Industry 4.0. In: Agile management and VUCA-RR: Opportunities and threats in Industry 4.0 towards Society 5.0. Bingley: Emerald Publishing Limited; 2022: 13-26.
2. Zhang G, Yang Y, Yang G. Smart supply chain management in Industry 4.0: the review, research agenda and strategies in North America. Ann Oper Res. 2023;322(2):1075-1117.
3. Gawade D. Agile Supply Chain in Manufacturing and Service Industry: Bibliometric and Content Analysis. Gawade D. Agile supply chain in manufacturing and service industry: Bibliometric and content analysis. Vision. 2023;27(2):167-177.
4. Lamming R. Squaring lean supply with supply chain management. Int J Oper Prod Manag. 1996;16(2):183-196.
5. Martínez MÁ, Herrera M, Contreras E, Ruíz A, Herrera-Viedma E. Characterizing highly cited papers in Social Work through H-Classics. Scientometrics. 2015;102:1713-1729.
6. Swenseth SR, Olson DL. Trade-offs in lean vs. outsourced supply chains. Int J Prod Res. 2016;54(13):4065-4080.
7. Hammou IA, Oulfarsi S, Hebaz A, Mahmah S, Cherrafi A. Lean, green, resilient supply chain and sustainable performance: Practices and measurements review. In: International Conference on Integrated Design and Production. Cham: Springer International Publishing. 2022: 59-76.
8. Rossetti CL, Warsing DP, Flynn BB, Bozarth CC. Complex and lean or lean and complex? The role of supply chain complexity in lean production. Oper Manag Res. 2023;16(3):1382-1412.
9. Womack JP, Jones DT. Lean thinking—banish waste and create wealth in your corporation. J Oper Res Soc. 1997;48(11):1148.
10. Moyano-Fuentes J, Bruque-Cámara S, Maqueira-Marín JM. Development and validation of a lean supply chain management measurement instrument. Prod Plan Control. 2019;30(1):20-32.
11. Garcia-Buendia N, Moyano-Fuentes J, Maqueira-Marín JM. A bibliometric study of lean supply chain management research: 1996–2020. Total Qual Manag Bus Excellence. 2022;33(15-16):1872-1895.
12. Abshire DM. US global policy: Toward an agile strategy. Wash Q. 1996;19(2):38-61.
13. Christopher M. The agile supply chain: competing in volatile markets. Ind Mark Manag. 2000;29(1):37-44.
14. Centobelli P, Cerchione R, Ertz M. Agile supply chain management: where did it come from and where will it go in the era of digital transformation? Ind Mark Manag. 2020;90:324-345.
15. Aronsson H, Abrahamsson M, Spens K. Developing lean and agile health care supply chains. Supply Chain Manag. 2011;16(3):176-183.
16. Van Oosterhout M, Waarts E, Van Hillegersberg J. Change factors requiring agility and implications for IT. Eur J Inf Syst. 2006;15(2):132-145.
17. De Diego E, Almodóvar P. Mapping research trends on strategic agility over the past 25 years: insights from a bibliometric approach. Eur J Manag Bus Econ. 2022;31(2):219-238.
18. Weber Y, Tarba SY. Strategic agility: A state of the art introduction to the special section on strategic agility. Calif Manag Rev. 2014;56(3):5-12.
19. Al-Omoush KS, Simón-Moya V, Sendra-García J. The impact of social capital and collaborative knowledge creation on e-business proactiveness and organizational agility in responding to the COVID-19 crisis. J Innov Know. 2020;5(4):279-288.
20. Hartwell CA, Devinney T. Populism, political risk, and pandemics: The challenges of political leadership for business in a post-COVID world. J World Bus. 2021;56(4):101225.
21. Zahra SA. International entrepreneurship in the post Covid world. J World Bus. 2021;56(1):101143.
22. Shaikh I. On the relation between the crude oil market and pandemic Covid-19. Eur J Manag Bus Econ. 2021;30(3):331-356.
23. Aldhaheri RT, Ahmad SZ. Factors affecting organisations' supply chain agility and competitive capability. Bus Process Manag J. 2023;29(2):505-527.
24. Zhang Y, Gu M, Huo B. Antecedents and consequences of supply chain agility: a competence-capability-performance paradigm. J Bus Ind Mark. 2023;38(5):1087-1100.
25. Elmoselhy SA. Hybrid lean–agile manufacturing system technical facet, in automotive sector. J Manuf Syst. 2013;32(4):598-619.
26. Qi YZ, Sheu XC. Lean, agile, and legile supply chain: A cumulative model. Dec Sci. 2011;42(2):371-389.
27. Aljoghaiman A, Rahman MA, Bauirzhanovna BA, Bhatti MA. Effects of supply chain strategy (lean, agile, hybrid) on Saudi firm performance: Exploring

mediating role of supply chain integration. Int J Constr Supply Chain Manag. 2022;12(2):124-142.
28. Fadaki M, Rahman S, Chan C. Leagile supply chain: design drivers and business performance implications. Int J Prod Res. 2020;58(18):5601-5623.
29. Mason-Jones R, Naylor B, Towill DR. Engineering the leagile supply chain. Int J Agile Manag Syst. 2000;2(1):54-61.
30. Bhamra R, Nand A, Yang L, Albregard P, Azevedo G, Corraini D, Emiliasiq M. Is leagile still relevant? A review and research opportunities. Total Qual Manag Bus Excellence. 2021;32(13-14):1569-1593.
31. Shahin A, Gunasekaran A, Khalili A, Shirouyehzad H. A new approach for estimating leagile decoupling point using data envelopment analysis. Assembly Autom. 2016;36(3):233-245.
32. Chan FT, Kumar V. Performance optimization of a leagility inspired supply chain model: a CFGTSA algorithm based approach. Int J Prod Res. 2009;47(3):777-799.
33. Shah A, Rose C, Ibrahim A, Khan SAR, Tanveer M. A resource and leagile strategy in business operations for performance improvement. Decis Anal J. 2023;7:100197.
34. Papadakis E, Tsironis L. Towards a hybrid project management framework: A systematic literature review on traditional, agile and hybrid techniques. J Mod Proj Manag. 2020;8(2):124-139.
35. Garcia-Buendia N, Moyano-Fuentes J, Maqueira-Marín JM, Cobo MJ. 22 Years of Lean Supply Chain Management: a science mapping-based bibliometric analysis. Int J Prod Res. 2021;59(6):1901-1921.
36. Zekhnini K, Cherrafi A, Bouhaddou I, Chaouni Benabdellah A, Bag S. A model integrating lean and green practices for viable, sustainable, and digital supply chain performance. Int J Prod Res. 2022;60(21):6529-6555.
37. Oliveira-Dias D, Garcia-Buendia N, Maqueira-Marín JM, Moyano-Fuentes J. Information technologies and lean and agile supply chain strategies: a bibliometric study through science mapping. Int J Bus Environ. 2021;12(4):338-363.
38. Raji IO, Rossi T, Strozzi F. A dynamic literature review on 'lean and agile' supply chain integration using bibliometric tools. Int J Serv Oper Manag. 2021;40(2):253-285.
39. Dabić M, Vlačić B, Paul J, Dana LP, Sahasranamam S, Glinka B. Immigrant entrepreneurship: A review and research agenda. J Bus Res. 2020;113:25-38.
40. Moral-Muñoz JA, Herrera-Viedma E, Santisteban-Espejo A, Cobo MJ. Software tools for conducting bibliometric analysis in science: An up-to-date review. Prof Inf. 2020;29(1):1-20.
41. Zhu J, Liu W. A tale of two databases: the use of Web of Science and Scopus in academic papers. Scientometrics. 2020;123(1):321-335.
42. Aria M, Cuccurullo C. bibliometrix: An R-tool for comprehensive science mapping analysis. J Informetr. 2017;11(4):959-975.
43. Van Eck N, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 2010;84(2):523-538.
44. Rodríguez-Ruiz F, Almodóvar P, Nguyen QT. Intellectual structure of international new venture research: A bibliometric analysis and suggestions for a future research agenda. Multinational Bus Rev. 2019;27(4):285-316.
45. Terjesen S, Hessels J, Li D. Comparative international entrepreneurship: A review and research agenda. J Manag. 2016;42(1):299-344.
46. Riehmann P, Hanfler M, Froehlich B. Interactive Sankey diagrams. In: IEEE Symposium on Information Visualization, 2005. INFOVIS 2005. New York: IEEE. 2005: 233-240.
47. Panizzolo R, Garengo P, Sharma MK, Gore A. Lean manufacturing in developing countries: evidence from Indian SMEs. Prod Plann Control. 2012;23(10-11):769-788.
48. Prashar A. Supply chain sustainability drivers for fast-moving consumer goods (FMCG) sector: an Indian perspective. Int J Prod Perform Manag. 2023;72(8):2397-2419.
49. Panwar A, Nepal BP, Jain R, Rathore APS. On the adoption of lean manufacturing principles in process industries. Prod Plann Control. 2015;26(7):564-587.
50. Koenig PC, Narita H, Baba K. Lean production in the Japanese shipbuilding industry? J Ship Prod. 2002;18(3):167-174.
51. Narassima MS, Aashrith V, Aldo Ronald C, Anbuudayasankar SP, Thenarasu M. Implementation of lean principles in the yarn manufacturing industry: a system dynamics approach. Benchmarking: An Int J. 2023 Dec 12. DOI: 10.1108/BIJ-05-2023-0324.
52. Oliveira-Dias D, Maqueira-Marín JM, Moyano-Fuentes J. The link between information and digital technologies of industry 4.0 and agile supply chain: Mapping current research and establishing new research avenues. Comput Ind Eng. 2022;167:108000.
53. Oliva FL, Couto MH, Santos RF, Bresciani S. The integration between knowledge management and dynamic capabilities in agile organizations. Manag Decis. 2018;57(8):1960-1979.
54. Zimmermann R, Ferreira LMD, Moreira AC. An empirical analysis of the relationship between supply chain strategies, product characteristics, environmental uncertainty, and performance. Supply Chain Manag. 2020;25(3):375-391.
55. Hashem G, Aboelmaged M. Leagile manufacturing system adoption in an emerging economy: an examination of technological, organizational, and environmental drivers. Benchmarking: An Int J. 2023;30(10):4569-4600.
56. Oliveira-Dias D, Moyano-Fuentes J, Maqueira-Marín JM. Understanding the relationships between information technology and lean and agile supply chain strategies: a systematic literature review. Ann Oper Res. 2022;312(2):973-1005.
57. Yang M, Fu M, Zhang Z. The adoption of digital technologies in supply chains: Drivers, process, and impact. Technol Forecast Soc Change. 2021;169:120795.
58. Mathiyazhagan K, Agarwal V, Appolloni A, Saikouk T, Gnanavelbabu A. Integrating lean and agile practices for achieving global sustainability goals in Indian manufacturing industries. Technol Forecast Soc Change. 2021;171:120982.