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Green and Resilient Automotive Supply Chains: Bibliometric and Systematic Review Toward Sustainable Manufacturing Competitiveness

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ABSTRAK

The automotive manufacturing industry is experiencing significant transformation driven by increasing global competition, supply chain complexity, and the rapid development of Industry 4.0 technologies. Traditional lean-oriented supply chains, which primarily focus on operational efficiency and waste reduction, are increasingly challenged by global disruptions, sustainability pressures, and the need for resilience. This study aims to analyze the development of research trends related to automotive supply chain transformation during the period 2015–2025, identify dominant research themes, and explore the role of Industry 4.0 technologies in supporting supply chain transformation within the automotive manufacturing sector. This study employs a Systematic Literature Review (SLR) combined with bibliometric analysis using data collected from the Scopus database. The analysis focuses on publications related to supply chain management and automotive manufacturing published between 2015 and 2025. The study examines publication trends, journal sources, leading authors, territorial distribution, and thematic evolution associated with Lean Supply Chain, resilience, sustainability, and Industry 4.0 technologies. The findings indicate a significant increase in research publications, particularly after the COVID-19 pandemic, reflecting a paradigm shift from efficiency-oriented supply chains toward resilient automotive ecosystems. The dominant research themes include Lean Supply Chain, digital transformation, supply chain resilience, and sustainability. Technologies such as Internet of Things (IoT), big data analytics, blockchain, and artificial intelligence play important roles in improving supply chain visibility, flexibility, and responsiveness. The study concludes that the integration of Lean Supply Chain, Industry 4.0, resilience, and sustainability has become a strategic direction for future automotive supply chain development. This research contributes to the literature by providing a comprehensive overview of the evolution of automotive supply chain transformation and highlighting future research opportunities in resilient and digital automotive ecosystems..

Keywords:
Green, Lean, Resilience, Supply Chain, Automotive Manufacturing

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1. Introduction

1.1 Background of the Study

The automotive manufacturing industry is a highly competitive sector globally and plays a crucial role in global economic growth [1][2]. Automotive companies are required to produce high-quality products at competitive costs, with fast delivery times, and the ability to adapt to dynamic market changes [3]. This requires companies to focus not only on internal production activities but also on the effectiveness and efficiency of the supply chain as a whole [4]. In recent decades, the Lean Supply Chain approach has become a dominant strategy for improving operational efficiency by reducing waste, improving material flow, and optimizing business processes throughout the supply chain [5].

However, the automotive industry's supply chain is highly complex, involving multi-tiered supplier networks, global distribution, and high interdependence between supply chain entities. Globalization expands cross-border supplier networks, allowing companies to benefit from production cost efficiencies and access to global resources [6]. On the other hand, this situation also increases the risk of supply chain disruption due to geopolitical instability, logistics delays, natural disasters, and fluctuations in market demand [7]. The complexity of relationships between suppliers, manufacturers, and distributors presents automotive companies with significant challenges in maintaining operational stability and material supply continuity [8].

Changes in the global business environment are increasingly pushing automotive companies to prioritize not only efficiency but also resilience and sustainability [9]. The lean approach, which previously focused on inventory minimization and process efficiency, has begun to face criticism for increasing supply chain vulnerability during major disruptions. [10] Therefore, the concept of a resilient supply chain is becoming increasingly important in building an organization's ability to anticipate, respond to, and recover from supply chain disruptions quickly and effectively [11]. Furthermore, pressure on sustainability is also increasing along with demands for environmental regulations, carbon emission reductions, and the implementation of green manufacturing in the global automotive industry.

In addressing these challenges, developments in Industry 4.0 technology offer significant opportunities for transforming the automotive supply chain toward a more adaptive, integrated, and data-driven system. Technologies such as the Internet of Things (IoT), big data analytics, blockchain, cloud computing, and artificial intelligence enable companies to improve visibility, traceability, and real-time decision-making capabilities [12][13]. The integration of digital technology into the supply chain helps companies increase operational flexibility, accelerate response to disruptions, and support the development of a more resilient and sustainable supply chain. This digital transformation is also driving a paradigm shift from the traditional lean supply chain to an intelligent and connected supply chain ecosystem [14].

Although research related to Lean Supply Chain, resilience, and Industry 4.0 continues to grow, existing studies tend to be fragmented and stand-alone. Most studies focus solely on improving lean manufacturing efficiency or adopting digital technologies without comprehensively integrating resilience aspects [15]. Furthermore, there is still limited research specifically addressing the transformation of the automotive industry supply chain from a traditional lean approach to a resilient automotive ecosystem based on Industry 4.0 [16]. This situation indicates the need for a systematic literature review to map research developments, identify key trends, and develop a conceptual framework capable of integrating Lean Supply Chain, resilience, and Industry 4.0 in the context of automotive supply chain transformation for the 2015–2025 period.

1.2 Research Gap

Although research on Lean Supply Chain, supply chain resilience, and Industry 4.0 has increased significantly in recent years, existing research still shows conceptual and methodological gaps. Most studies discuss lean supply chain as an approach to improving operational efficiency, while others focus more on the implementation of Industry 4.0 technologies or resilience strategies separately. This situation has resulted in a lack of a comprehensive understanding of the relationship and integration of these three concepts in the context of supply chain transformation in the automotive industry.

Furthermore, previous research is still dominated by partial approaches that only highlight certain aspects, such as digital technology adoption, operational efficiency, or risk management individually [17]. However, the dynamics of the modern automotive industry demonstrate that lean efficiency alone is no longer sufficient to face global uncertainty and increasingly complex supply chain disruptions. A supply chain approach is needed that is not only efficient but also adaptive, flexible, and capable of maintaining operational continuity in conditions of disruption. However, research that simultaneously integrates lean capability, digital

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transformation, and resilience capability is still relatively limited [18].

The research gap is also evident in the lack of systematic literature reviews that specifically map the development of Industry 4.0-based automotive supply chain transformation in the post-pandemic period. Most previous reviews are general in nature, focusing on the manufacturing sector or focusing on a single theme, such as green supply chain or smart manufacturing. Few studies have explored how the paradigm shift occurs from a traditional lean supply chain to a resilient automotive ecosystem supported by digital technology and interconnected systems [19][20].

Based on this situation, this study seeks to fill this research gap through a systematic literature review that integrates the perspectives of Lean Supply Chain, resilience, and Industry 4.0 in the context of automotive industry supply chain transformation for the 2015–2025 period. This study not only maps publication trends and dominant research themes but also develops a conceptual framework that illustrates the relationships between key concepts in building a resilient automotive ecosystem based on digital transformation. Therefore, this research is expected to provide theoretical and practical contributions to the development of a more adaptive, sustainable, and competitive automotive supply chain.

1.3 Research Objectives

Penelitian ini bertujuan untuk menganalisis perkembangan penelitian mengenai transformasi supply chain industri otomotif berbasis Industry 4.0 dalam periode 2015–2025 melalui pendekatan systematic literature review. Secara khusus, penelitian ini bertujuan untuk mengidentifikasi tren publikasi, tema penelitian dominan, serta perkembangan konsep Lean Supply Chain, resilience, dan digital transformation dalam konteks supply chain otomotif global. Selain itu, penelitian ini juga bertujuan untuk mengeksplorasi hubungan antar konsep utama yang membentuk resilient automotive ecosystem di era Industry 4.0.

- Menganalisis tren perkembangan publikasi penelitian terkait automotive supply chain transformation periode 2015–2025.
- Mengidentifikasi tema-tema penelitian dominan yang berkaitan dengan Lean Supply Chain, resilience, sustainability, dan Industry 4.0 dalam industri otomotif.
- Mengeksplorasi peran teknologi Industry 4.0 seperti Internet of Things (IoT), big data analytics, blockchain, dan artificial intelligence dalam mendukung transformasi supply chain otomotif.

2. Research Method

2.1 Research Design

This study uses a Systematic Literature Review (SLR) approach to analyze research developments on Industry 4.0-based automotive supply chain transformation during the 2015–2025 period. The SLR approach was chosen because it allows for systematic, transparent, and structured identification, evaluation, and synthesis of literature. Furthermore, this study combines bibliometric analysis to map publication trends, the development of research themes, and the relationships between keywords in the field of automotive supply chain transformation.

The bibliometric approach is used to obtain a quantitative overview of research developments, such as annual publication trends, dominant themes, and interrelationships between research topics. Thus, the combination of SLR and bibliometric analysis allows this study to produce a more comprehensive literature mapping related to Lean Supply Chain, resilience, sustainability, and Industry 4.0 in the automotive industry.

2.2 Data Source

The research data source was obtained from the Scopus database because it is one of the largest scientific databases and has a wide coverage of international publications and high quality. Article data was collected in May 2026 with a publication range from 2015 to 2025. The selection period was based on the increasing development of research on Industry 4.0, digital supply chains, and supply chain resilience in the last decade, especially after the COVID-19 pandemic. The articles used in this study consist of journal articles, conference papers, and review articles relevant to the topic of supply chain transformation in the automotive industry. All bibliographic data was exported in CSV format to facilitate the process of bibliometric analysis and literature classification.

2.3 Search Strategy

The article search process was carried out using the Scopus database by utilizing a combination of keywords relevant to the research topic, namely supply chain management and automotive manufacturing. The search strategy was systematically arranged using Boolean operators to ensure that the articles obtained were in accordance with the research focus on the transformation of the automotive industry supply chain. The search queries used in this study were as follows (TITLE-ABS-KEY (Supply chain management) AND TITLE-ABS-KEY (automotive manufacturing)) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (

DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English")).

2.4 Screening and Selection Process

The article screening and selection process was carried out in stages to ensure that the articles used were in line with the research focus. The first stage was carried out by collecting all articles from the Scopus database based on a predetermined search query. Next, the titles, abstracts, and keywords of the articles were examined to identify their suitability to the research topic regarding supply chain management in the automotive manufacturing industry. At this stage, irrelevant and duplicate articles were eliminated from the analysis process. After the screening process was completed, articles that met the inclusion criteria were selected as the final research data. These articles were then used in a systematic literature review and bibliometric analysis to identify research trends, dominant themes, and developments in the automotive industry's supply chain transformation based on Industry 4.0 during the period 2015–2025.

3. Result

3.1 Publication Trend Analysis

The analysis shows that research on supply chain transformation in the automotive manufacturing industry experienced a significant increase during the 2015–2025 period. The increasing number of publications indicates that supply chain management is becoming a strategic topic in the automotive industry, especially with the increasing complexity of global supply chains and the development of Industry 4.0 technologies. In the initial period, 2015–2018, the number of publications was relatively limited and dominated by research related to lean manufacturing, operational efficiency, and supplier management. The focus of research during this period emphasized increasing operational efficiency, reducing waste, and optimizing supply chain processes to enhance the competitiveness of the automotive industry.

Entering the 2019–2021 period, there has been increased attention to the topics of digital transformation and supply chain resilience. This trend is influenced by the development of Industry 4.0 technologies such as the Internet of Things (IoT), big data analytics, cloud computing, and blockchain, which are increasingly being implemented in automotive supply chain systems. Furthermore, the COVID-19 pandemic has been a significant factor driving the shift in research direction from efficiency-oriented supply chains to resilience-oriented supply chain ecosystems. Global distribution disruptions, semiconductor supply constraints, and international logistics instability are raising attention to the importance of supply chain visibility, flexibility, and risk mitigation.

In the 2022–2025 period, research trends indicate a shift toward integrating Lean Supply Chain, sustainability, resilience, and digital technologies. Research is no longer solely focused on operational efficiency, but is shifting toward developing intelligent and resilient automotive ecosystems based on data and digital technology. Topics such as sustainable supply chains, smart manufacturing, green logistics, and digital supply chain integration are becoming dominant themes in scientific publications.

Overall, the results of the publication trend analysis indicate an evolution of the automotive industry supply chain research paradigm from a lean and operational excellence approach to a more adaptive, integrated, and resilient approach through the use of Industry 4.0 technology.

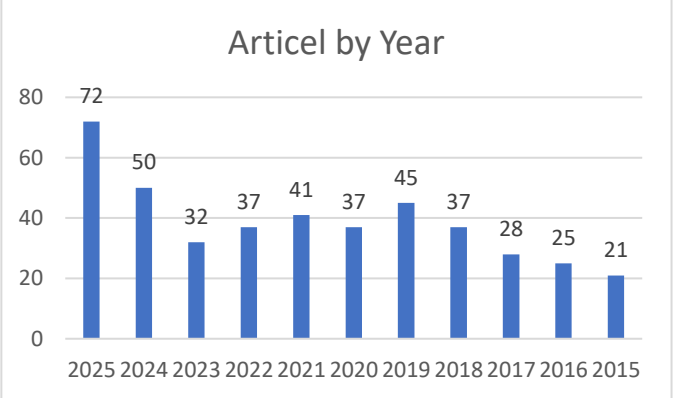

Fig.1 Article by Year

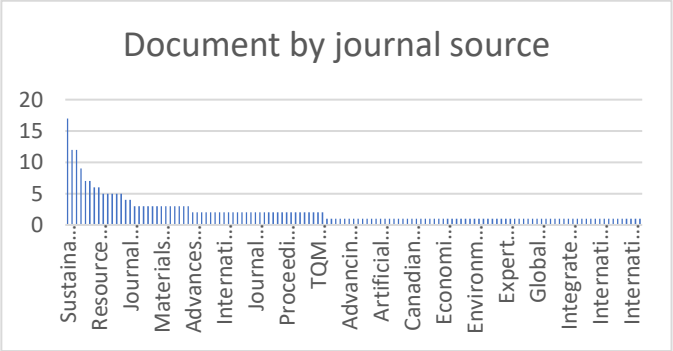

Fig 2. Document by Journal Sources

The analysis shows that research on automotive supply chain transformation has increased significantly during the 2015–2025 period. The number of publications increased gradually from 21 documents in 2015 to 72 documents in 2025, indicating increasing attention to Industry 4.0-based supply chain transformation, resilience, and sustainability in the automotive industry.

The increase in publications after the COVID-19 pandemic indicates a shift in research focus from lean and operational efficiency approaches to a resilient automotive ecosystem that is more adaptive to global disruption, as seen in Figure 1. Based on publication sources, the journals Sustainability Switzerland, Journal of Cleaner Production, and Lecture Notes in Mechanical Engineering are the dominant sources, indicating a strong link between research and sustainability, digital transformation, and green manufacturing, as seen in Figure 2.

Furthermore, the author's analysis shows that Luthra, S. and Mangla, S.K. is the most productive author in this research field, followed by several other researchers who discuss resilience, digital supply chain, and sustainable manufacturing, details can be seen in figure 3. In terms of regional distribution, India is the country with the highest number of publications, followed by China, the United States, the United Kingdom, and Germany, as in figure 4. The dominance of these countries shows the high attention to the development of supply chain management and digital transformation in the automotive manufacturing sector. Meanwhile, developing countries such as Thailand, Malaysia, and Indonesia have also begun to show contributions in automotive supply chain transformation research as part of efforts to increase industrial competitiveness through the application of Industry 4.0 technology and supply chain resilience.

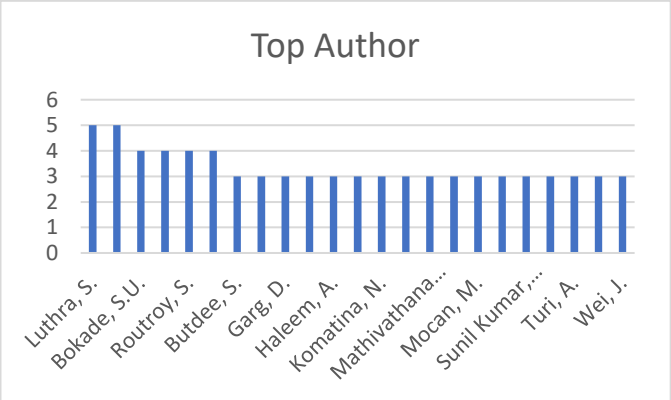

Fig 3. Top Author

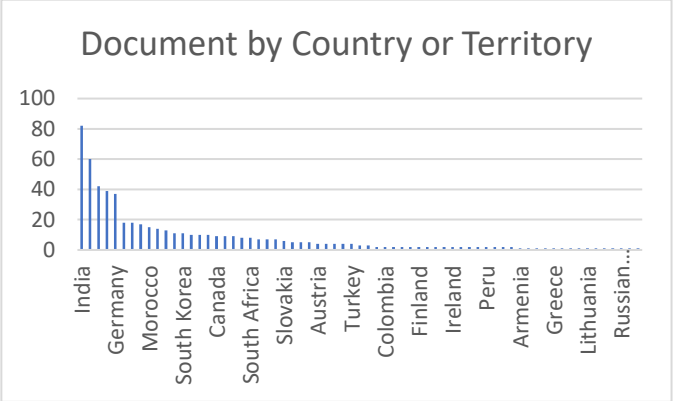

Fig 4. Document by Country or Territory

3.2 Dominant Research Themes

Based on the results of keyword analysis and thematic clustering, several dominant research themes emerged in automotive supply chain transformation studies during the 2015–2025 period. These themes indicate the direction of automotive supply chain research development, which is increasingly integrated with digital transformation and resilience capability.

The first theme is Lean Supply Chain and Operational Excellence. Research in this cluster focuses on improving operational efficiency through lean manufacturing, waste reduction, process optimization, and supplier integration. Lean remains a key foundation in the automotive industry supply chain due to its ability to increase productivity and lower operational costs.

The second theme is Industry 4.0 and Digital Supply Chain Transformation. This theme has experienced the most significant development in recent years. Research in this cluster discusses the implementation of technologies such as IoT, big data analytics, blockchain, cloud computing, and artificial intelligence to improve visibility, traceability, and real-time decision-making in the automotive supply chain. Digital transformation is seen as a crucial factor in creating a more flexible and responsive supply chain to changes in the business environment.

The third theme is Supply Chain Resilience and Risk Management. Research in this theme has grown rapidly, especially following the COVID-19 pandemic. The main focus of the research includes supply disruption management, resilience capability, agility, flexibility, and supply chain recovery strategy. Research shows that the automotive supply chain requires high adaptability to face global uncertainty and large-scale operational disruptions.

The fourth theme is Sustainability and Green Supply Chain. Research in this group addresses green manufacturing, sustainable logistics, carbon emission reduction, and the circular economy in the automotive industry. Sustainability has become a critical issue due to increasing environmental regulatory pressure and

demands for more environmentally friendly business practices.

Thematic analysis results indicate that automotive supply chain research is moving toward an integration of lean capability, digital transformation, resilience, and sustainability. This integration demonstrates a shift in the modern supply chain paradigm, which focuses not only on efficiency but also on sustainability and resilience to global disruptions.

3.5 Research Theme Interpretation

Based on keyword analysis and thematic clustering, research on automotive supply chain transformation is dominated by four main themes: Lean Supply Chain, Industry 4.0, supply chain resilience, and sustainability. In the initial research period, the primary focus was on lean manufacturing, operational efficiency, supplier integration, and waste reduction as strategies to increase productivity in the automotive industry. However, with the increasing complexity of global supply chains and the development of digital technology, research themes have evolved toward digital supply chain transformation through the application of the Internet of Things (IoT), big data analytics, blockchain, and artificial intelligence in automotive supply chain systems.

Furthermore, the COVID-19 pandemic has become a significant factor accelerating the development of research related to resilience and sustainability in the automotive supply chain. Research has begun to emphasize the importance of supply chain visibility, flexibility, agility, and risk mitigation in facing global disruptions. This situation indicates a paradigm shift from the traditional lean supply chain to a more integrated, adaptive, and resilient automotive ecosystem based on Industry 4.0 technology. The integration of lean capability, digital transformation, resilience, and sustainability has become the primary direction for the development of the modern automotive supply chain.

4. Disscussion

The research results show that the development of automotive supply chain research has undergone significant changes during the 2015–2025 period. Initially, research focused more on Lean Supply Chain and operational efficiency through waste reduction, increased productivity, and supply chain process optimization. However, the increasing complexity of global supply chains, the development of digital technology, and the impact of the COVID-19 pandemic have shifted the direction of research toward supply chain resilience and digital transformation. This situation demonstrates that the automotive industry no longer requires only an efficient supply chain, but also a system that is flexible, adaptive, and resilient to global disruptions.

The development of Industry 4.0 technology is a key factor in the supply chain transformation of the modern automotive industry. Technologies such as the Internet of Things (IoT), big data analytics, blockchain, and artificial intelligence enable increased visibility, traceability, and real-time decision-making in supply chain management. The implementation of digital technology helps companies improve supply chain agility, responsiveness, and risk mitigation capabilities. Thus, Industry 4.0 functions not only as an operational support technology but also as a strategic enabler in building a resilient automotive ecosystem based on digital integration.

Furthermore, this study shows that sustainability and resilience are beginning to emerge as integrated concepts within the automotive industry supply chain. Pressures for green manufacturing, environmental regulation, and sustainable business practices are driving companies to develop supply chains that are not only efficient and resilient, but also sustainable. Therefore, the integration of Lean Supply Chain, Industry 4.0, resilience, and sustainability is becoming a new paradigm in the development of the modern automotive supply chain. These findings suggest that the future transformation of the automotive supply chain will increasingly lead to an intelligent, connected, and sustainable automotive ecosystem..

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