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Review Article

The Role of Blockchain Technology in Supply Chain and Logistics Sector: A Literature Review for the Period 2015-2024

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ABSTRACT

This study systematically analyzes 50 academic publications focusing on blockchain applications in supply chain and logistics processes between 2015 and 2024. Following a systematic literature review method based on PRISMA principles, comprehensive searches were conducted in databases including Google Scholar, ScienceDirect, ResearchGate, SpringerLink, IEEE Xplore, and Wiley Online Library using relevant keywords. From an initial pool of 135 publications, 50 studies were selected based on clear inclusion and exclusion criteria for detailed analysis. The introduction outlines blockchain's benefits in supply chains such as transparency, reliability, and traceability. The literature review categorizes blockchain applications into key themes including IoT integration, smart contracts, and fraud prevention. Developmental trends and thematic evolution over the decade are visualized and critically examined. The evaluation and conclusion sections offer a critical assessment of the literature, highlighting challenges such as scalability, energy consumption, and regulatory gaps. The study further emphasizes the importance of regulatory frameworks with country-specific examples and proposes actionable directions for future research. Overall, the study underscores blockchain's significant potential to enhance reliability, sustainability, and operational efficiency in supply chain management, while calling for more applied research and sector-specific adaptations.

Keywords: *Blockchain, supply chain management, transparency and reliability, IoT integration, smart contracts*

Blok Zinciri Teknolojisinin Tedarik Zinciri ve Lojistik Sektöründeki Rolü: 2015-2024 Dönemi Literatür Taraması

ÖZ

Bu çalışma, 2015-2024 yılları arasında tedarik zinciri ve lojistik süreçlerinde blok zincir uygulamalarına odaklanan 50 akademik yayını sistematik olarak analiz etmektedir. PRISMA ilkelerine dayanan sistematik literatür tarama yöntemi kullanılarak, Google Scholar, ScienceDirect, ResearchGate, SpringerLink, IEEE Xplore ve Wiley Online Library gibi veri tabanlarında ilgili anahtar kelimelerle kapsamlı aramalar gerçekleştirilmiştir. Başlangıçta taranan 135 yayından, belirlenen dahil etme ve hariç tutma kriterleri doğrultusunda 50 çalışma detaylı analiz için seçilmiştir. Giriş bölümünde, blok zincirin tedarik zincirlerindeki şeffaflık, güvenilirlik ve izlenebilirlik gibi faydaları ele alınmaktadır. Literatür

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taraması, blok zincir uygulamalarını IoT entegrasyonu, akıllı sözleşmeler ve dolandırıcılık önleme gibi ana temalar altında sınıflandırmaktadır. On yıllık dönemdeki gelişim eğilimleri ve tematik evrim görselleştirilerek eleştirel bir şekilde incelenmiştir. Değerlendirme ve sonuç bölümleri, ölçeklenebilirlik, enerji tüketimi ve düzenleyici boşluklar gibi zorlukları vurgulayarak literatürü eleştirel biçimde değerlendirmektedir. Çalışma ayrıca ülke bazlı örneklerle düzenleyici çerçevelerin önemini vurgulamakta ve gelecekteki araştırmalar için uygulanabilir öneriler sunmaktadır. Genel olarak çalışma, blok zincirin tedarik zinciri yönetiminde güvenilirlik, sürdürülebilirlik ve operasyonel verimliliği artırma potansiyelini ortaya koymakta ve daha fazla uygulamalı araştırma ile sektöre özgü uyarlamalara ihtiyaç olduğunu ifade etmektedir.

Anahtar Kelimeler: *Blok zinciri, tedarik zinciri yönetimi, şeffaflık ve güvenilirlik, IoT entegrasyonu, akıllı sözleşmeler*

I. INTRODUCTION

As complex networks of global trade, supply chains have traditionally struggled with structural problems such as information asymmetry, security vulnerabilities and lack of transparency. These problems reduce the efficiency of supply chains, increase costs and undermine consumer confidence. In recent years, blockchain technology, which has come to the fore as a solution to these problems, is also known as distributed ledger technology. This technology opens the doors to a radical transformation in supply chains thanks to its security, transparency and immutability.

A blockchain is a secure and encrypted database held jointly by multiple computers. Every transaction made in this database is sent simultaneously to computers across the entire network and added to the chain as a block. The cryptographic linking of each block to the previous block makes it almost impossible to change the data. In this way, blockchain offers permanent solutions to security and transparency problems in supply chains.

The use of blockchain technology in supply chains provides a wide range of benefits, from verifying the origin of products, optimising logistics processes, preventing counterfeiting and using smart contracts. Since each stage of the process from production to consumption can be tracked on the blockchain, consumers can access reliable information about the true origin of products, production conditions and transport processes. This contributes to achieving sustainability goals by increasing consumer confidence in supply chains.

The aim of this study is to evaluate the current situation in this field by comprehensively analysing 50 different academic studies on the applications of blockchain technology in supply chains between 2015 and 2024. In this study, the innovations brought by blockchain technology to supply chains, the challenges it faces and its future potential will be emphasised. In the study, firstly, academic studies carried out between 2015-2024 will be included. Then, in the light of the academic studies, the application areas of blockchain in different sectors, the benefits it provides and the main problems it offers solutions will be detailed.

In addition, the technical and operational limitations identified in the literature and the barriers to the widespread adoption of blockchain technology will be discussed. Finally, in line with the findings, implications for future research directions in this area and the potential impact of the technology on supply chain management in the long term will be drawn.

II. LITERATURE REVIEW

A. LITERATURE REVIEW METHOD

In this study, systematic literature review method was adopted. The review process was carried out in accordance with the principles of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The literature review process was structured in line with the criteria described below:

Databases Used:

- Google Scholar
- ScienceDirect
- ResearchGate
- SpringerLink
- IEEE Xplore
- Wiley Online Library

Keywords Used:

- 'Blockchain' AND 'Supply Chain'
- 'Blockchain Technology' AND 'Logistics'
- 'Smart Contracts' AND 'Traceability'
- 'Distributed Ledger' AND 'Supply Chain Transparency'
- 'IoT Integration' AND 'Blockchain Supply Chain'

Inclusion Criteria

1. Time Period:
   Studies published between 2015 and 2024.
2. Subject Matter Relevance:
   Studies on the applications of blockchain technology directly in supply chain management and logistics processes.
3. Technological Depth:
   Studies with technological or operational depth such as smart contracts, IoT integration, data security, traceability, sustainability.
4. Full Text Accessibility:
   Accessibility of the entire study (articles that are not limited to abstracts and can be content analysed).

Exclusion Criteria

1. Superficial Content:
   Publications that only scratch the surface of blockchain and do not provide detailed technical or operational implementation.
2. Non-Supply Chain Focus:
   Studies that examine blockchain applications in different sectors such as health, finance, education, but are not related to the supply chain.
3. Repetitive Publications:
   Publications with the same content or repetitive publications in more than one source.
4. Theoretical Study Intensity:
   Superficial theoretical publications that contain only general conceptual explanations and do not provide technological, operational or sectoral depth in the supply chain context.

Selection Process:
The PRISMA flow diagram below shows how 135 studies were screened and ultimately 50 studies were selected:

Table 1. *Literature Selection Process (PRISMA Table)*

	Stage	Number of Records
0	Initial records inentified	135
1	Duplicates removed (Exclusion Criterion 3)	-10
2	Excluded based on abstract/title review – superficial content (Exclusion Criterion 1)	-30
3	Excluded due to non-supply chain focus (Exclusion Criterion 2)	-20
4	Excluded for being purely theoretical (Exclusion Criterion 4)	-25
5	Total studies included in the review	50

B. LITERATURE RESULTS

Research in 2015 examined the potential benefits of blockchain technology in the areas of supply chain, logistics and security. In this context, Bateman stated that traceability is a critical element in terms of product safety, operational efficiency and sustainability in the supply chain, and emphasised that the decentralised and transparent structure of blockchain technology can solve these problems [1]. Daskalos stated that blockchain offers an important solution for improving supply chain security and monitoring financial transactions. However, he emphasised that the risk of not adopting this technology by all stakeholders may be an obstacle [2]. Godbole analysed the potential of integration with ERP systems to increase financial security and data integrity, and stated that it provides cost savings and data security in the long term [3]. Herbert and Litchfield stated that a secure and flexible verification mechanism can be created by using blockchain in software licence verification processes [4]. Swan stated that by using blockchain in supply chain and logistics processes in the automotive sector, a secure system can be created by providing traceability from vehicle production to the end user. He also emphasised that machine-to-machine communication between vehicles and smart contracts have significant potential in optimising logistics processes [5].

Research in 2016 examined the potential of blockchain technology to provide transparency, security and efficiency in supply chain and logistics processes. In this context, Badzar discussed the blockchain's ability to reduce information asymmetry in the supply chain, increase the traceability of environmental impacts and secure processes with smart contracts. In this way, he stated that businesses can improve their sustainability policies [6]. Kurki examined the potential of blockchain to provide security, traceability and operational efficiency in the pharmaceutical supply chain, emphasising that it can play a critical role in preventing counterfeit products and preventing logistics disruptions [7]. Mattila stated that blockchain provides reliable data sharing in the supply chain and can increase consumer confidence by preventing counterfeiting. He also mentioned that with the integration of smart contracts, processes can be automated and cost savings will be achieved [8]. Milani et al. stated that blockchain can optimise processes by providing transparency, reliability and traceability in the supply chain, and also stated that smart contracts can play an important role in automation and error reduction [9]. Tian designed a system that aims to ensure food safety and traceability through the integration of RFID and blockchain in the Chinese agri-food supply chain. He stated that this system aims to reduce product losses and logistics costs by quickly solving food safety problems [10].

Research in 2017 addressed how blockchain technology can be used to provide security, transparency and process optimisation in logistics and supply chains. In this context, Alvarez-Diaz et al. highlighted that smart contracts provide data transparency and increase operational efficiency by using the Ethereum blockchain to increase security and automate processes in logistics management [11]. Hackius and Petersen examined the potential of blockchain in providing transparency and data security, and stated

that efficiency gains can be achieved by preventing counterfeit products in the supply chain, digitising documents and automating processes [12]. Iyengar drew attention to the advantages of blockchain in providing traceability and security in the rice supply chain, and stated that all processes can be traced in a decentralised network, providing quality assurance [13]. Korpela et al. explored the potential of blockchain to provide transparency and data security in digital supply chain integration, while emphasising the acceleration of B2B data integration and reducing dependency on intermediary institutions [14]. Madhwal and Panfilov demonstrated the potential of blockchain in the production and distribution of aircraft parts to provide counterfeit prevention, traceability and transparency throughout the supply chain. These studies comprehensively addressed the potential of blockchain to make supply chain processes more reliable, transparent and efficient [15].

Research in 2018 examined the potential of blockchain technology to provide transparency, security and efficiency in the supply chain. These studies show that digital transformation in supply chains is accelerating and how blockchain is transforming these processes. In this context, Handoyo et al. emphasised the potential of blockchain to provide transparency and trust in the supply chain and discussed its integration with RFID and IoT Technologies [16]. Kubac discussed the importance of RFID and blockchain integration in terms of counterfeit detection and data security, and stated that costs can be reduced by automating processes [17]. Lanko et al. examined the integration of blockchain and RFID technologies in the construction industry and revealed the potential to accelerate processes by increasing data security [18]. Perboli et al. discussed how blockchain can increase transparency and reliability in the food supply chain and reduce logistics costs [19]. Yoo and Won aimed to provide price transparency and increase trust in the supply chain by developing a blockchain-based price monitoring system. These studies comprehensively addressed the potential of blockchain to transform supply chain processes and increase sectoral efficiency [20].

Research in 2019 examined the potential of blockchain technology in supply chain management and the benefits it offers to the sector. In this context, Astarita et al. examined the applications of blockchain technology in the transport sector. In their study, they discussed how blockchain technology can be used in areas such as supply chain, logistics and smart cities, and examined the potential contributions of this technology in terms of sustainability and security. However, they emphasised that the technology is still at an early stage and more research is needed [21]. Corengia and Moreschi addressed the value creation potential of blockchain technology in the supply chain and discussed how traceability, transparency and trust can be increased. They examined the contribution of blockchain to reduce transaction costs and improve food safety, especially in the Western European dairy industry [22]. Layaq et al. discussed the role of blockchain in reducing risks in the supply chain and drew attention to the potential of this technology, which increases visibility, traceability and reliability, to accelerate processes with quality control and smart contracts [23]. Onay et al. proposed an Ethereum-based smart contract system to provide reliability and transparency during the transport of environmentally sensitive products. With this system, processes are made safer by monitoring temperature and humidity data during transport [24]. Öz and Gören examined the advantages of blockchain such as traceability, reliability and cost optimisation in the supply chain and demonstrated that logistics processes can become more efficient and faster thanks to smart contracts and IoT integration [25].

Research in 2020 focused on the potential of blockchain technology to provide transparency, security and efficiency in supply chain management. These studies have examined the effects of blockchain in different sectors in depth with the acceleration of the digital transformation process. In this context, Kartskhiya et al. discussed the contribution of blockchain to key supply chain objectives such as cost, speed, quality and sustainability, as well as the economic value and legal regulations of digital assets (cryptocurrencies, tokens) [26]. Azimov aimed to solve the problems in logistics cycles with blockchain and emphasised that the speed of operation increases with digitalisation [27]. Wang et al. demonstrated that blockchain can be used as a critical tool in monitoring and managing carbon footprint by improving collaboration in the supply chain [28]. Xie et al. examined the integration of blockchain and financing in the railway transport sector, aiming to increase efficiency in the sector and create new earning models [29]. Kifokeris and Koch demonstrated the potential of blockchain in integrating the three main flows in the supply chain with the innovative digital business model they developed for construction logistics

consultants. These studies have discussed the benefits that can be achieved by integrating the technology, taking a broad view of the potential of blockchain to transform supply chain processes and increase sectoral efficiency [30].

Research in 2021 explored the advantages of blockchain technology in supply chains, such as transparency, security and efficiency. In this context, Arbatskaya and Khoreva highlighted the role of blockchain in providing digitalisation, reliability and transparency in ecotourism logistics, reducing costs and increasing data security through decentralised transactions [31]. Kozhanov and Woebbeking stated that blockchain reduces counterfeiting and quality problems by increasing transparency and security in the supply chain, and also supports sustainable development with the solutions it offers in food safety and drug transport [32]. Liu and Guo revealed that blockchain provides efficiency by increasing security and logistics traceability in fresh food e-commerce supply chains and strengthens cooperation among supply chain members [33]. Santoso and Yulia stated that blockchain optimises supply chain processes with its transparency and traceability features and plays an important role in preventing counterfeit products and ensuring sustainability, especially in the pharmaceutical, automotive and food sectors [34]. Sharma et al. emphasised that blockchain makes supply chains more resilient by providing flexibility and transparency in managing disruptions and risks in food supply chains during the COVID-19 pandemic. These studies show that blockchain technology is an important tool in providing transparency, security and sustainability in supply chains [35].

Research in 2022 addressed various aspects of blockchain technology's potential to provide transparency, security and efficiency in supply chain processes. In this context, Kazancoglu et al. focused on the impact of the COVID-19 pandemic on sustainable food supply chains, examined the advantages and risks of blockchain adaptation in reverse logistics processes, and suggested strategies on issues such as data security and operational integration, revealing that blockchain can strengthen the fragile structure of the supply chain [36]. Rathod et al. proposed a blockchain-based system with Ethereum-based smart contracts, ensuring the traceability of products and emphasising the elimination of intermediaries as well as reducing costs by preventing counterfeit products [37]. Santhi and Muthuswamy stated that blockchain technology provides data security and transparency in the manufacturing supply chain and offers advantages such as preventing counterfeit products and automating manual processes. He also drew attention to limitations such as scalability and energy consumption [38]. Yan et al. examined the cost-effectiveness and transparency potential of blockchain-based supply chains and showed that this technology makes significant contributions to reducing operational costs and improving information sharing [39]. Yontar, on the other hand, investigated the integration of blockchain with the circular economy and emphasised that blockchain is an important tool in achieving goals such as reducing carbon emissions and reducing logistics costs. These studies reveal that blockchain technology has significant potential in providing transparency, security, efficiency and sustainability in supply chains [40].

Studies conducted in 2023 examined the advantages of blockchain technology such as transparency, security and traceability in supply chains. In this context, Gazzola et al. stated that blockchain provides transparency and sustainability in the food sector, especially in Lavazza's coffee supply chain, environmental data is made traceable with blockchain [41]. Panda and Mazumder developed a blockchain platform that improves organ traceability in the kidney transplant supply chain, and Qiu et al. proposed a blockchain-based traceability model to provide data security and optimisation in digital supply chains [42, 43]. Yogarajan et al. discussed the advantages of blockchain in the agri-food supply chain, while Spitalleri et al. proposed a solution to fraud and security problems in the food supply chain with the BioTrak platform [44, 45]. These studies reveal that blockchain is an important tool in providing transparency, trust and sustainability in supply chains.

2024 studies have revealed that blockchain technology has significant impacts on supply chains and that this technology provides operational efficiency, security and transparency in various sectors. In this context, Dash et al. addressed the potential of blockchain to reduce logistics losses in pharmaceutical supply chains, aiming to provide traceability and transparency to combat problems such as counterfeiting and theft [46]. Kim and AlZubi examined the integration of blockchain and artificial

intelligence in the supply chains of organic pulses, and stated that these two technologies provide transparency by reducing the risks of counterfeiting with the synergistic effect of these two technologies [47]. Lan emphasised the potential of blockchain to reduce information asymmetry in supply chains, provide transparency and traceability, and make significant contributions in the fields of green supply chains and sustainability [48]. Qin et al. investigated the integration of blockchain technology in smart logistics systems and emphasised that this system increases logistics efficiency and reduces costs [49]. Revathi et al. discussed the role of blockchain in providing transparency, traceability and security, especially in the pharmaceutical industry, and discussed the challenges of blockchain applications in large-scale supply chains such as scalability and transaction speed [50]. These studies show that blockchain is a powerful tool for providing transparency, security, traceability and sustainability in supply chains.

III. EVALUATION

A. MAIN THEMES AND TRENDS IN BLOCKCHAIN BASED SUPPLY CHAIN STUDIES

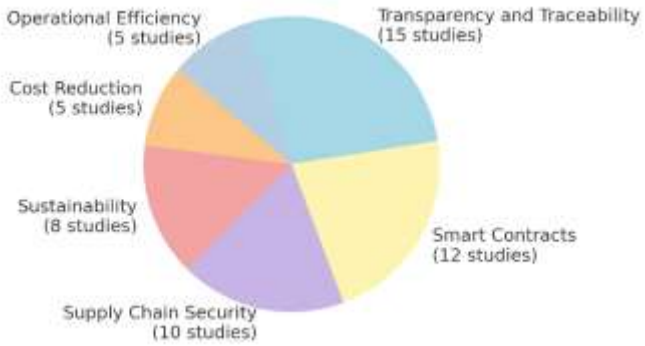

Figure 1. *Basic Themes in Blockchain Based Supply Chain Studies*

The prominent themes in Figure 1 are detailed in Table 2, and case studies and content foci for each theme are presented.

Table 2. *Themes and Sample Publications in Blockchain Based Supply Chain Studies (2015-2024)*

Theme	Sample Studies (Author, Year)	Description
Transparency and Traceability (15)	Bateman (2015), Kurki (2016), Mattila (2016), Tian (2016), Hackius & Petersen (2017), Iyengar (2017), Handoyo (2018), Kubac (2018), Perboli (2018), Corengia & Moreschi (2019), Sharma (2021), Liu & Guo (2021), Panda (2023), Qiu (2023), Dash (2024)	End-to-end tracking of products, data transparency, consumer confidence
Smart Contracts (12)	Swan (2015), Badzar (2016), Mattila (2016), Álvarez-Díaz (2017), Milani (2016), Layaq (2019), Onay (2019), Rathod (2022), Yan (2022), Qin (2024), Öz & Gören (2019), Santhi (2022)	Process automation, digital contracts, intermediary-free transaction execution
Supply Chain Security (10)	Daskalos (2015), Kurki (2016), Madhwal & Panfilov (2017), Kubac (2018), Kozhanov (2021), Gazzola (2023), Revathi (2024), Liu & Guo (2021), Dash (2024), Godbole (2015)	Fraud prevention, data security, risk mitigation

Table 2(cont). *Themes and Sample Publications in Blockchain Based Supply Chain Studies (2015-2024)*

Sustainability (8)	Bateman (2015), Badzar (2016), Wang (2020), Kozhanov (2021), Kazancoglu (2022), Gazzola (2023), Lan (2024), Yontar (2022)	Carbon footprint tracking, green logistics, environmental sustainability
Cost Reduction (5)	Godbole (2015), Mattila (2016), Revathi (2024), Yan (2022), Rathod (2022)	Elimination of intermediaries, reduction of unnecessary costs
Operational Efficiency (5)	Swan (2015), Álvarez-Díaz (2017), Liu & Guo (2021), Qin (2024), Xie (2020)	Process acceleration, workforce and resource optimisation

Table 2 above, prepared in line with Figure 1, provides the matching of the themes with the sample studies. In this context, the contextual density of the themes and their reflections in the literature are evaluated below.

Figure 1 presents the main themes addressed by academic studies examining the applications of blockchain technology in supply chain and logistics processes between 2015 and 2024. The reviewed studies generally focus on topics such as **transparency and traceability** (15 studies) and **smart contracts** (12 studies). The emphasis on these themes highlights the potential of blockchain technology to make information flow in supply chains reliable and automate processes.

Other important issues include **supply chain security** (10 studies) and **sustainability** (8 studies). This finding reveals that blockchain has the capacity to not only increase operational efficiency but also to create more sustainable logistics systems by reducing security threats such as fraud and data manipulation.

In addition, the themes of **operational efficiency** and **cost reduction** (5 studies each) show that blockchain is gaining more and more attention in terms of contributing to efficiency and reducing costs in logistics management processes.

These data emphasise that the role of blockchain technology in supply chain management is multidimensional and provides various benefits in different fields of study. Therefore, future research and applications should evaluate these advantages of blockchain more broadly and conduct in-depth analyses on a sectoral basis.

A. 1. Thematic Evolution and Transformation

When the studies in the 2015-2024 period are analysed, it is observed how blockchain themes have transformed and diversified over time. While basic concepts such as traceability, transparency and security were at the forefront in early studies; in the following years, practical themes such as smart contracts, IoT integration and operational efficiency came to the fore. After 2020, strategic orientations such as sustainability, crisis management and regulation attract attention. In particular, the COVID-19 pandemic has made the crisis resilience aspects of blockchain more visible.
Themes develop by feeding and transforming each other. For example, the theme of transparency has become intertwined with sustainability over time, while smart contracts have led to outcomes such as cost reduction and operational efficiency. This reveals the dynamic nature of the conceptual framework in the literature and the layered development of the impact of technology on sectors.

A. 2. Chronological Development of Thematic Evolution

The academic literature on the use of blockchain technology in supply chain processes has undergone a thematic evolution in line with changing needs and technological developments over time. This evolution has transformed both research foci and application areas, ranging from transparency and traceability to sustainability and strategic regulations.

A. 2015-2017: Exploration and Basic Concepts
This early work focussed on exploring the potential of blockchain technology. Key themes such as transparency, traceability and security have often emerged in the literature. These themes are based on the potential of the decentralised structure offered by the technology to prevent counterfeiting, track product movements and enhance data security. For example, studies such as Bateman (2015) and Kurki (2016) have discussed how information asymmetry in the supply chain can be addressed by blockchain.

B. 2018-2020: Technical Integration and Applications
In this period, the technical integration of blockchain technology into supply chain processes has come to the fore. Prominent themes include smart contracts, IoT integration and operational efficiency. There are now studies focusing on concrete applications rather than the theoretical potential of the technology. In this context, significant contributions have been made in areas such as RFID-based tracking systems, automated data flow and process automation (e.g. Handoyo, 2018; Perboli, 2018; Wang, 2020).

C. 2021-2022: Sustainability and Crisis Focused Approaches
In this period, the themes of sustainability, crisis resilience and circular economy have come to the fore with the impact of the COVID-19 pandemic. The literature shows that blockchain responds to post-crisis requirements such as reducing the fragility of supply chains and increasing traceability. Sharma et al. (2021) emphasised how disruptions in food supply chains are managed with blockchain. In addition, green logistics practices that contribute to environmental sustainability have also attracted attention in this period.

D. 2023-2024: Regulation, Artificial Intelligence and Strategic Alignment
Recent studies have focused on themes such as regulatory compliance, integration with artificial intelligence and strategic transformation required for the integration of blockchain into the supply chain. In this context, blockchain systems working together with AI enable the development of intelligent decision support mechanisms. At the same time, the European Union's regulatory frameworks such as eIDAS 2.0 pave the way for more widespread adoption of the technology [51]. Kim and AlZubi (2024) show that the combination of blockchain and artificial intelligence increases security in organic product supply chains.

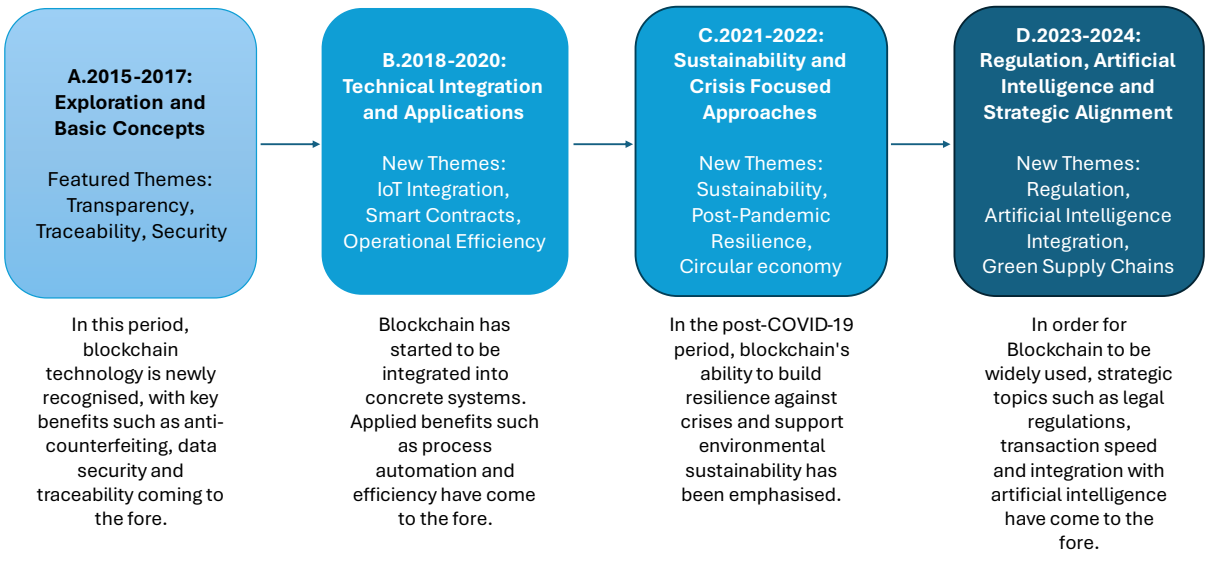

Figure 2. *Chronological Distribution of Thematic Evolution in Blockchain-Based Supply Chain Literature between 2015-2024*

In summary, the timeline given in Figure 2 shows around which themes and in which periods the integration of blockchain technology into the supply chain is concentrated in the reviewed literature.

While basic concepts such as transparency and security were at the forefront in the early years, more advanced themes such as technical integration, sustainability and strategic alignment came to the fore in the following years.

B. CRITICAL EVALUATION AND RECOMMENDATIONS

This systematic review has revealed both the strengths and limitations of existing academic studies on the integration of blockchain technology into supply chain and logistics processes. While many studies emphasize blockchain's transformative potential—particularly in enhancing traceability, transparency, and operational efficiency—there remain several recurring gaps that limit the practical utility and interdisciplinary expansion of current research. Below, we present a structured critique of these gaps along with actionable recommendations.

1. Overreliance on Theoretical Frameworks
A significant portion of the literature remains heavily conceptual, with limited inclusion of real-world use cases or empirical validations. While theoretical models are essential for foundational understanding, the lack of applied case studies hinders the field's progression toward implementation.
Recommendation:
Future research should prioritize empirical investigations, including pilot applications, longitudinal studies, and sector-specific implementations. Comparative case analyses across industries (e.g., food vs. pharmaceutical supply chains) can provide actionable insights into technology adaptation under varying operational and regulatory constraints.

2. Insufficient Treatment of Technical and Operational Constraints
Although challenges such as scalability, energy consumption, and interoperability are frequently mentioned, they are often addressed only in passing. This superficial treatment limits our understanding of how to design more efficient, resilient blockchain-based supply chain systems.
Recommendation:
Future studies should examine these technical limitations in more detail, especially focusing on practical challenges they create. Questions such as how scalability issues can be addressed, how energy consumption can be reduced, and how different systems can work together more effectively should be explored. In addition, comparing how these limitations affect different sectors may also provide useful insights for the literature.

3. Limited Cross-Sectoral Integration and Siloed Analyses
Most reviewed studies focus narrowly on single industries—such as agriculture, pharmaceuticals, or automotive—without exploring cross-industry synergies or transferable solutions. This siloed approach restricts the scalability and generalizability of findings.
Recommendation:
Interdisciplinary frameworks should be developed to explore how blockchain applications in one sector (e.g., cold-chain logistics in food) can be adapted to others (e.g., vaccine transport in healthcare). Cross-sector learning is essential to uncover shared best practices and implementation strategies.

4. Underdeveloped Discourse on Legal and Regulatory Frameworks
Few studies thoroughly engage with the legal, institutional, and policy dimensions of blockchain integration. Regulatory uncertainty remains one of the most cited barriers to adoption, yet specific country-level responses are underrepresented in the literature.

Recommendation:
Future studies should integrate comparative legal analyses, highlighting policy models from blockchain-adaptive countries such as Estonia, South Korea, and members of the European Union (e.g., eIDAS 2.0 regulations) [52]. These cases provide instructive templates for digital identity, data governance, and cross-border trust systems.

5. Surface-Level Discussion of IoT and Smart Contract Integration

Although the convergence of blockchain with IoT and smart contracts is acknowledged as transformative, most studies lack a technical or security-focused exploration of these integrations.

Recommendation:
Scholars should investigate the interoperability, data validation, latency, and cybersecurity risks involved in multi-technology supply chain systems. Special attention should be paid to the standardization of data formats, security protocols, and real-time processing.

Final Remarks
While blockchain technology offers immense promise for supply chain transformation, its academic discourse must now move beyond foundational enthusiasm to critically examine conditions for scalable, secure, and context-sensitive deployment. The above recommendations aim to shift future research toward actionable insights, practical frameworks, and interdisciplinary collaboration.

IV. CONCLUSION

This study has systematically reviewed 50 academic publications published between 2015 and 2024, focusing on the implementation of blockchain technology in supply chain and logistics management. By applying a PRISMA-based methodology and defining clear inclusion/exclusion criteria, the study contributes a structured and transparent approach to existing literature reviews in the field. Unlike prior fragmented reviews, this research presents a consolidated thematic classification and examines the chronological evolution of key concepts—such as transparency, traceability, sustainability, and smart contracts—offering a longitudinal perspective on how blockchain adoption has matured over time.

Findings indicate that blockchain technology provides significant advantages in enhancing transparency, ensuring traceability, improving operational efficiency, and supporting sustainability goals. However, several critical limitations remain prevalent across the literature, including a lack of real-world implementation case studies, limited cross-sectoral applicability, superficial treatment of technical barriers such as scalability and energy consumption, and inadequate exploration of legal and regulatory frameworks.

To address these gaps, the study not only deepens the discussion on these challenges but also introduces concrete regulatory examples from countries like Estonia, South Korea, and members of the European Union. These cases highlight how legal infrastructure can play a decisive role in facilitating blockchain adoption and offer a blueprint for future research into policy design.

Furthermore, this review introduces a visual thematic mapping and tabulated classifications, offering researchers and practitioners a comprehensive reference framework. These visual tools, along with the structured analysis of thematic transitions over time, can guide future studies aiming to investigate blockchain adoption in a more integrated, application-oriented, and sector-specific manner.

In conclusion, while blockchain technology continues to show great promise for transforming supply chain systems, its full potential will only be realized through interdisciplinary collaboration, regulatory innovation, and empirically grounded research. Future studies are encouraged to bridge the gap between theory and practice by developing scalable, secure, and sector-adaptable blockchain solutions grounded in both technological and socio-political realities.

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