

Optimization and Simulation Techniques in Construction Supply Chains: A Systematic Review and Bibliometric Analysis

AMAL GARNI¹, ABDELLAH EL BARKANY¹, FAOUAZ JEFFALI² and OUMAYYA HECHLAF³,

¹ Science and Engineering Research Laboratory, Faculty of Science and Techniques, Sidi Mohamed Ben Abdellah University, Fez, Morocco

² Laboratoire des Matériaux, Ondes, Energie et Environnement, Faculté des Sciences, Université Mohammed Premier, Oujda, Morocco

³ Laboratory of Advanced Research of in Industrial and Logic Engineering, Hassan II University, Casablanca, Morocco

a.garni89@gmail.com, abdellah.elbarkany@usmba.ac.ma, f.jeffali@ump.ac.ma, Oumayya.hechlaf@gmail.com

Abstract. The growing complexity of construction projects and the need for sustainability have made supply chain optimization a crucial factor in enhancing performance, resilience, and decision-making. This study conducts a systematic review and bibliometric analysis of research on optimization and simulation techniques applied to construction supply chains. Based on 340 selected publications from Scopus and Web of Science (1997–2024), the analysis identifies key research trends, major contributors, and emerging themes, highlighting the field's multidisciplinary and collaborative nature. Using Biblioshiny, the study examines scientific output, citation metrics, and coauthorship networks, revealing a 15.05% annual growth rate and 31.47% international collaboration. Keyword analysis and visualization techniques, such as cooccurrence maps and thematic clustering, illustrate the evolution of research in this domain. The findings offer valuable insights for academics and practitioners, emphasizing the role of optimization and simulation in improving the efficiency and sustainability of construction supply chains.

1 Introduction

Construction, a sector historically marked by fragmentation and delays, is now faced with the imperatives of rationalizing logistics and reducing environmental impact. The integration of optimization and simulation techniques offers powerful levers for meeting these challenges. The aim of this article is to examine scientific trends, major contributors and emerging themes through a dual methodological approach.

2 Methodology

For a thorough review, we looked through three major scholarly databases: Google Scholar, which provides extensive access to academic papers, technical reports, and essays; Web of Science, which is renowned for citation analysis and high-impact research; and Scopus, which is known for conference proceedings and peer-reviewed articles. The most recent developments in AI applications for production scheduling were also accessed by consulting IEEE Xplore and SpringerLink [23]. Using key terms like "Master Production Schedule," "Industry 4.0," and "Artificial Intelligence," along with other related keywords, the search technique was methodical. The search was expanded using boolean operators such as "MPS AND AI" and "Optimization AND Big Data." To restrict articles to 2014–2024, filters were used, with an emphasis on English and French-language research, especially those from the engineering and industrial management fields.

Bibliometric analysis was carried out using the Biblioshiny tool, enabling us to examine indicators such as annual scientific output, growth rate (15.05%), average age of publications (4.25 years), and average number of citations per article (21.67). The study also reveals a significant wealth of terminology, with 1187 "Keywords Plus" and 1291 author keywords, reflecting the diversity and multidisciplinary nature of the field.

The data also show strong scientific cooperation, with an average of 3.62 co-authors per paper and 31.47% international collaborations. Only 20 articles were published individually, confirming the collaborative and interdisciplinary nature of research in this field.

Finally, visualization techniques were used (word clouds, co-occurrence maps, thematic analyses), and bibliometric laws such as Bradford's and the H-index were applied to better identify the influence of the most prolific sources and authors.

In terms of citations, the average per article has risen sharply, peaking between 2018 and 2020, testifying to the growing impact of recent publications, particularly those incorporating artificial intelligence models and sustainability criteria.

A study of the most relevant journals reveals that Sustainability (Switzerland), European Journal of Operational Research and IEEE Access are the most productive and influential sources, according to the Bradford principle and the H-index. These journals dominate knowledge dissemination, both in terms of volume and citations.

The evolution of publications by journal shows a progressive specialization of the field:

- Sustainability has become a leader, in line with the growing focus on environmental issues.
- European Journal of Operational Research retains a central role for classical quantitative approaches.
- IEEE Access illustrates the integration of digital technologies in logistics research.

3 Results

3.2 BIBLIOMETRIC ANALYSIS OF PUBLICATIONS

Analysis of the results highlights a significant growth in scientific production on optimization and simulation techniques applied to construction supply chains, particularly from 2015 onwards. This dynamic can be explained by the rise of advanced technologies such as artificial intelligence and Big Data, which offer new capabilities for modeling and managing complex logistics flows.

Three phases characterize this evolution:

- A period of latency (2000-2014), marked by low production and still marginal interest in the subject.
- A take-off phase (2015-2019), coinciding with the emergence of digital technologies and environmental concerns.
- A phase of rapid expansion (2020- 2022), stimulated by the COVID-19 pandemic, reinforced climate policies, and the maturity of digital tools, with a peak in publications in 2022.

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These results confirm that the optimization and simulation of construction supply chains has evolved from an emerging field to an established area of research, strongly influenced by the digital transition and sustainability requirements.

3.3 MAIN PARTICIPANTS AND COLLABORATIONS

The analysis of scientific contributions reveals that China, the United States, and the United Kingdom are the major hubs of production in the field of optimization and simulation of construction supply chains. These countries stand out both in terms of publication volume and the density of their international collaborations, which enhances the reach and visibility of their research.

Among the most influential authors, Wang H., Zhang X., and Zhang Y. distinguish themselves with a sustained output (five publications each), suggesting a deep specialization and a significant contribution to the methodological advancement of the field. Li X. and Sakas D. (four publications each), along with other authors such as Chen W., Liu Y., and Talluri S. (three publications), also enrich the domain through their work on automation, simulation, and the integration of smart technologies.

The evolution of individual research trajectories shows a balance between established researchers and new entrants. The most productive figures exhibit notable consistency and high academic impact, measured notably by the number of annual citations. The variations observed in publication trends also suggest the existence of structured collaboration networks, fostering the emergence of multidisciplinary approaches.

Regarding the countries of affiliation of corresponding authors, China overwhelmingly leads, followed by the United States and the United Kingdom. While some countries, such as Italy, Iran, and India, adopt a mixed dynamic between local production and international collaborations, others, like Indonesia and South Africa, remain on the margins of global cooperation networks. This geographical imbalance reflects disparities in access to scientific resources and international partnerships.

Finally, the mapping of scientific production by country confirms the concentration of expertise around three regional hubs: East Asia, North America, and Western Europe. China, accounting for nearly 40% of total production, benefits from a favorable ecosystem for innovation in the construction sector. Europe, though less prolific, contributes to specific technological niches, particularly in sustainability. Emerging countries are gradually positioning themselves but remain underrepresented, especially in Africa, with the notable exception of South Africa.

3.4 EMERGING THEMES

Lexical analysis has highlighted several emerging themes shaping research on the optimization and simulation of supply chains in the construction sector. These studies reveal a gradual convergence toward issues linking performance, technology, and sustainability. At the core of the field, the concepts of 'optimization' and 'supply chain management' appear as traditional pillars, reflecting a strong technical focus on improving operational efficiency. Terms such as 'algorithm,' 'system,' and 'performance' further illustrate the growing importance of computational approaches and digital technologies in logistics management. At the same time, the emergence of notions such as 'sustainability,' 'carbon emission,' and 'green' indicates a rising interest in integrating environmental considerations into logistics models. However, these concerns remain somewhat peripheral compared to purely optimization-focused approaches, reflecting a tension between productivity demands and sustainability requirements.

- A visual analysis using word clouds and tree maps reveals a structuring around three major thematic poles:
- A technical axis, dominated by algorithms and systems,
- A managerial axis, focused on performance and logistics coordination,
- An ecological axis, still secondary but expanding, centered on sustainability and emissions reduction

The temporal evolution of keywords shows an increasing specialization of the field: while early publications focused on general concepts, more recent research has shifted toward more targeted sub-themes, such as 'network design,' 'decision-making,' or 'multi-objective optimization.' The growing prominence of terms like 'big data' and 'artificial intelligence' reflects the widespread adoption of predictive analytics tools and intelligent hybrid models. Finally, semantic cluster analysis highlights strong connections between technical concepts (optimization, simulation), organizational aspects (management, coordination), and environmental considerations (sustainability, green supply chain). This convergence suggests a maturation of the field toward more integrated approaches, while also emphasizing the need for a methodological rebalancing to position sustainability as a central rather than peripheral factor in logistics optimization strategies.

4 Discussion

The factorial analysis based on keyword cooccurrences provides a deeper understanding of the conceptual structure of the literature on optimization and simulation of supply chains in construction. This type of visualization offers an in-depth reading of thematic relationships and highlights both dominant and emerging research areas.

The key driving themes, positioned on the right axis of the factorial map—such as 'optimization,' 'supply chain management,' and 'sustainability'—hold a central and welldeveloped place in the literature. They form the theoretical backbone of the field and serve as the foundation for most recent studies. Their centrality attests to their scientific maturity and their structuring role in logistics management models.

Conversely, emerging or niche themes like 'big data,' 'technology,' or 'challenges' appear on the periphery. Their position suggests either a recent rise in prominence, driven by technological advancements and the need for post-crisis resilience, or a low density of treatment in existing literature. These topics represent future research opportunities, particularly for developing innovative and multidimensional approaches.

Based on this analysis, an integrated conceptual model is proposed:

- Optimization is identified as the core of the system. It drives logistics strategy and structures all decision-making processes.
- Advanced technologies (big data, artificial intelligence) act as performance levers, feeding optimization models with real-time data and predictive analytics capabilities.
- Performance and sustainability are the two interdependent objectives of this model: economic efficiency gains must be accompanied by environmental progress (waste reduction, better resource allocation).
- Supply chain management serves as the integrating framework, connecting technological tools, optimization practices, and sustainability goals in a systemic and resilient approach.

This model highlights a holistic approach to managing construction supply chains, where technological, strategic, and environmental dimensions are interconnected through optimized and data-driven management.

5 Conclusion

This research offers a structured mapping of the field of logistics optimization applied to construction, identifying advances, dominant trends and gaps to be filled. It proposes a conceptual framework focusing on optimization as a driver of performance and sustainability, supported by advanced technologies. Future research would benefit from more in-depth empirical assessments and the exploration of geographical contexts that are still poorly covered.

References

1. Mansouri, SA; Gallear, D; Askariazad, MH Decision support for build-to-order supply chain management through multiobjective optimization
2. Elmachtoub, AN; Levi, R Supply Chain Management with Online Customer Selection
3. Hu, J; Li, XT Construction and Optimization of Green Supply Chain Management Mode of Agricultural Enterprises in the Digital Economy
4. Zhong, ZZ; Zhao, EY Collaborative Driving Mode of Sustainable Marketing and Supply Chain Management Supported by Metaverse Technology
5. Puche, J; Ponte, B; Costas, J; Pino, R; de la Fuente, D Systemic approach to supply chain management through the viable system model and the theory of constraints
6. Ang, J; Fukushima, M; Meng, FW; Noda, T; Sun, J Establishing Nash equilibrium of the manufacturer-supplier game in supply chain management
7. Nurakhova, B; Ilyashova, G; Torekulova, U QUALITY CONTROL IN DAIRY SUPPLY CHAIN MANAGEMENT
8. Meriton, R; Bhandal, R; Graham, G; Brown, A An examination of the generative mechanisms of value in big data-enabled supply chain management research
9. Lin, HF; Lin, J; Wang, F An innovative machine learning model for supply chain management
10. Tayyab, M SUSTAINABLE PRODUCTION DELIVERY MECHANISM FOR THIRDGENERATION BIODIESEL SUPPLY CHAIN MANAGEMENT UNDER TECHNOLOGY INVESTMENT AND MULTISHIPMENT POLICY
11. Lejarza, F; Pistikopoulos, I; Baldea, M A scalable real-time solution strategy for supply chain management of fresh produce: A Mexico-to-United States cross border study
12. Pathy, SR; Rahimian, H Value of risk aversion in perishable products supply chain management
13. Lieckens, K; Vandaele, N; Differential evolution to solve the lot size problem in stochastic supply chain management systems
14. Tliche, Y; Taghipour, A; MahfodLeroux, J; Vosooghidizaji, M Collaborative Bullwhip Effect Oriented Bi-Objective Optimization for Inference-Based Weighted Moving Average Forecasting in Decentralized Supply Chain

15. Özkanlısoy, O; Bulutlar, F; Measuring Supply Chain Performance as SCOR v13.0-Based in Disruptive Technology Era: Scale Development and Validation
16. Salawu, YO; Ghadiri, SM; Roles of trade logistics to the development of international trade: A perspective of Nigeria
17. Ada, N Sustainable Supplier Selection in Agri-Food Supply Chain Management
18. Farmand, N; Zarei, H; Rasti-Barzoki, M Two meta-heuristic algorithms for optimizing a multi-objective supply chain scheduling problem in an identical parallel machines environment
19. Nabhani, F; Uhl, C; Kauf, F; Shokri, A Supply chain process optimisation via the management of variance
20. Ribeiro, JP; Barbosa-Póvoa, APFD A responsiveness metric for the design and planning of resilient supply chains
21. Niknejad, A; Petrovic, D Optimisation of integrated reverse logistics networks with different product recovery routes
22. Chen, SP Effects of fuzzy data on decision making in a competitive supply chain
23. Ghomi, V; Gligor, D; Shokoohyar, S; Alikhani, R; Nezami, FG An optimization model for collaborative logistics among carriers in vehicle routing problems with cross-docking
24. May, A; Anslow, A; Ojiako, U; Wu, Y; Marshall, A; Chipulu, M Optimisation of key performance measures in air cargo demand management
25. Miranda, MA; Alvarez, MJ; Briand, C; Moris, MU; Rodríguez, V Ecoefficient management of a feeding system in an automobile assembly-line
26. Panicker, VV; Reddy, MV; Sridharan, R Development of an ant colony optimisation-based heuristic for a location-routing problem in a twostage supply chain
27. Yadavalli, VSS; Balcou, C A supply chain management model to optimise the sorting capability of a 'third party logistics' distribution centre
28. Abdussalam, O; Fello, N; Chaabane, A Exploring options for carbon abatement in the petroleum sector: a supply chain optimization-based approach
29. Hashmi, H; Khan, NR; Haq, MA; THE IMPACT OF LEAN MANAGEMENT IMPLEMENTATION ON ORGANIZATIONAL OPERATIONAL PERFORMANCE
30. Badakhshan, E; Ball, P A simulationoptimization approach for integrating physical and financial flows in a supply chain under economic uncertainty
31. Wang, CC Logistic Analytics Management in the Service Supply Chain Market Using Swarm Intelligence Modelling
32. Allesina, S; Azzi, A; Battini, D; Regattieri, A. Performance measurement in supply chains: new network analysis and entropic indexes
33. Ren, TH; Zeng, NM; Wang, DF; Cheng, SW EFFECTS OF CHANNEL ENCROACHMENT ON THE SOFTWARE AND SERVICE DECISIONS IN IT SUPPLY CHAINS
34. Xu, L; Shi, XR; Du, P; Govindan, K; Zhang, ZC. Optimization on pricing and overconfidence problem in a duopolistic supply chain