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Applications of Operations Research in Sustainable Supply Chain Optimisation

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ABSTRACT

Operations research (OR) is extensively applied to model cost-emission-resilience compromises in sustainable supply chains, yet the previous literature reviews concentrate mainly on a particular methodological or problematic issue. This article provides a bibliometric analysis of 3,521 Scopus journal articles and reviews published between 2016 and 2027. Bibliometrix tools were used to explore the trends and patterns in the selected literature pieces. The number of papers increased significantly during the timeline, from 77 SCOPUS-indexed documents in 2016 to 803 documents in 2025. A few highly cited documents dominate the distribution, while no single group of authors is more productive than the others. Multi-objective and robust optimisation studies have the largest share of keywords, but the central themes are circular economy, artificial intelligence, and machine learning. According to the identified research frontiers, this article offers a research agenda that consists of six thematic areas and directions of OR applications.

Keywords: *Operations Research, Sustainable Supply Chain, Supply Chain Optimisation, Closed-Loop Supply Chain, Bibliometric Analysis*

1. INTRODUCTION

Supply chains carry most of the environmental burden of modern economic activity. For the typical consumer-goods company, the supply chain accounts for more than 80% of greenhouse-gas emissions and more than 90% of the impact on air, land, water, biodiversity and geological resources (Bové & Swartz, 2016). Corporate disclosure data show the same imbalance: in 2023, companies reporting to CDP recorded supply chain (Scope 3) emissions that were, on average, 26 times higher than their direct operational emissions, and only 15% of them had set a target for those emissions (Boston Consulting Group & CDP, 2024). These figures explain why sustainable supply chain management, understood as the management of material, information and capital flows across companies while balancing economic, environmental and social goals, has become a worldwide concern for firms, regulators and investors (Seuring & Müller, 2008).

Operations research (OR) gives this concern a decision-making method. OR expresses a supply chain problem, such as where to locate a facility, how much to produce, which supplier to select or which route to use, as a mathematical model with objectives, constraints and decision variables, and then searches for the best feasible solution. Dekker et al. (2012) showed how OR methods can support green logistics decisions, while Brandenburg et al. (2014) found that quantitative models for sustainable supply chain management concentrated on economic and environmental objectives, with the social dimension receiving far less attention. Because the body of such work has grown too large to be read paper by paper, the present study went through the literature using

bibliometric analysis, which reads a field through the patterns in its publications, citations, authors and keywords, and so shows how OR is being applied, where it is concentrated and where it is thin (Donthu et al., 2021).

The motivation for this study comes from the pace of growth in this literature and the way earlier reviews are organised. Reviews of OR-based sustainable supply chain research have mostly been built around one method or one problem type, for example multi-objective optimisation (Jayarathna et al., 2021), closed-loop network models (Lozano-Oviedo et al., 2024) or metaheuristic algorithms (Faramarzi-Oghani et al., 2023). Such reviews are valuable, but a field-wide picture of how the whole literature has developed, who is driving it and which parts remain weakly connected is harder to read from them. The need for that picture has become sharper because annual output in the dataset analysed here rose from 77 papers in 2016 to 803 in 2025, with almost half of all records appearing in the last two years.

The study is therefore linked directly to the application of OR: it treats OR-based modelling for sustainable supply chains as the object of analysis and asks where research effort has gone and where it should go next. The paper follows the stages of the study. A literature review first sets out the conceptual background, the evidence on how OR methods handle multiple objectives, uncertainty, circularity and resilience, and the main research gaps. The methodology then describes a Scopus search carried out on 10 September 2026 with the keywords "Sustainable AND supply chain AND optimization", which returned 5,802 records. Following the PRISMA 2020 logic adapted for bibliometric work (Page et al., 2021), the records were screened by time span (2016–2027), document type (articles and reviews), language (English) and source type (journals), which left 3,521 papers for analysis. The dataset was examined with Biblioshiny, the web interface of the bibliometrix R package (Aria & Cuccurullo, 2017), supplemented by a script that read the RIS and BibTeX exports directly, in line with the performance-analysis and science-mapping approach described by Donthu et al. (2021).

The bibliometric analysis then covers publication trends, sources, citation patterns, author productivity, keywords and thematic structure. Output grew from 77 papers in 2016 to 803 in 2025, and the 2026 count of 859 was already the highest in the file even though the export was taken in September. Sustainability (Switzerland) and the Journal of Cleaner Production are the leading outlets, and citations are highly concentrated, with the top 10% of papers holding 53.4% of all citations. The most-cited documents are the circular economy review by Kalmykova et al. (2018) and the sustainable supplier selection framework of Luthra et al. (2017), while the industry 5.0 study by Akundi et al. (2022) reached 455 citations in only four years. Authorship is widely dispersed, with about 82% of author names appearing on a single paper. Optimisation terms, led by multi-objective and robust optimisation, dominate the keywords, and the thematic map places circular economy, artificial intelligence and machine learning in the most central and best-developed position.

Based on these patterns, the paper closes with a future research agenda that identifies six gaps: the distorting effect of citation lag on recent work, the structural limits of the underlying bibliographic data, the unproven status of the circular economy–artificial intelligence cluster, the separation between the field's broad management vocabulary and its technical optimisation core, a convergence with energy and process engineering that is visible only in journal choice, and a dispersed, weakly coordinated authorship base. Several of these gaps echo concerns already raised in the literature, such as the difficulty of quantifying social impacts in optimisation models (Messmann et al., 2020) and the call for clearer research priorities in circular supply chain design (Langenaeker et al., 2026). The conclusion then returns to the objectives of the study and sets out its implications and limitations.

2. RESEARCH METHODOLOGY

Different authors have measured systematic literature review (SLR) techniques in a variety of ways and prior studies to strengthen the foundation of knowledge. (Paul & Rialp, 2020) . Structured literature reviews are typically completed through an iterative cycle of defining appropriate search keywords, searching the literature, and completing the analysis, thus scholars recommend a structured methodology for scanning resources, designing the mind map to structure the literature review, writing the study and building the bibliography (Fahimnia et al., 2015). The present study identifies and analyses the research trends in the application of operations research in sustainable supply chain optimisation.

2.1 Article selection, inclusion, exclusion criteria

A search was conducted on 10 September 2026 on Scopus database using the search keywords "Sustainable AND supply chain AND optimization" which generated 5802 papers in total. These keywords ensured that the results obtained were consistent with the topic scope of research. Next, the search results were saved, and each article included all possible information for subsequent analysis such as the title, the author(s), the abstract, the affiliation(s), the keywords, and the reference list.

The principal study of the experimental approach was limited to research results up to 2016, covering 10 years of data, resulting in an initial exclusion of 442 papers which ranged between 1995 to 2015. This was done to make sure the data results are skewed towards the recent past and papers were not very old.

Moreover, the study excluded papers according to the document type such as conference papers, book chapters, editorials, data papers and short surveys which were 1715 in number. These were excluded due to their irrelevance for the given topic structure. The search results were inclusive of engineering, computer science, environmental science, energy, business management & accounting, decision sciences, mathematics and other subject areas, which were selected for its appropriateness and validity towards the subject. Eligibility criteria required the study results to be in English only, thus, 113 papers which were found in languages like Chinese, Spanish, Portuguese, French, Russian and others were eliminated. Once the samples were extracted, 11 papers were further removed as the source type was limited to journal type papers. This resulted in an overall exclusion of 2281 research papers, leaving a total of 3521 papers for further analysis.

2.2 Bibliometric Analysis

Bibliometric analysis is a popular and rigorous method for exploring and analysing large volumes of scientific data. It enables us to unpack the evolutionary nuances of a specific field, while shedding light on the emerging areas in that field(Donthu et al., 2021)).

Bibliometric analysis is about studying the patterns of publications and citations in a group of papers. It helps to show the shape and ideas of a research area. It finds out who is writing, where, how often and how topics change over time based on details like how many times a paper is cited, the words used, who wrote them and when they were published.

Moreover, bibliometric analysis is adopted in this research due to three major reasons. First, compared to other analysis methods such as content analysis, bibliometric analysis is easier and relatively more reliable to handle hundreds of articles. Second, bibliometric analysis can deeply analyse the relationships among articles, citations, co-citations and keywords, and thus the results can provide comprehensive information for our research field. The final reason is the strong visualization ability for bibliometric analysis, which helps readers easily and clearly identify their future research interests in the field. (Feng et al., 2017)

The study for the given topic of sustainable supply chain optimisation utilised biblioshiny through R studio. The search results were stored in RIS and bibtex format to include all the essential paper information such as paper title, authors' names and affiliations, abstract, keywords and references.

The data was collected using Scopus Database and imported to Mendeley Desktop for the purpose of references and citations. The database was also imported to biblioshiny using Rstudio and an excel sheet was generated afterwards for further data cleaning. The Study employed Vos viewer and tableau which are software tools used to build and view visual maps of scientific literature and research networks for our study.

The PRISMA 2020 statement has been designed primarily for systematic reviews of studies that evaluate the applications of operations research in the topic area of sustainable supply chain optimisation (Page et al., 2021). The conduct of a systematic review depends heavily on the scope and quality of included studies; thus, systematic studies were modified from their original review protocol during its conduct. (Moher et al., 2010). The Prisma statement provides an overview of all the inclusion and exclusion criterions used and how many papers were included after each step of identification, screening, eligibility and inclusion for finalising the dataset for further analysis.

The Prisma flowchart is as follows:

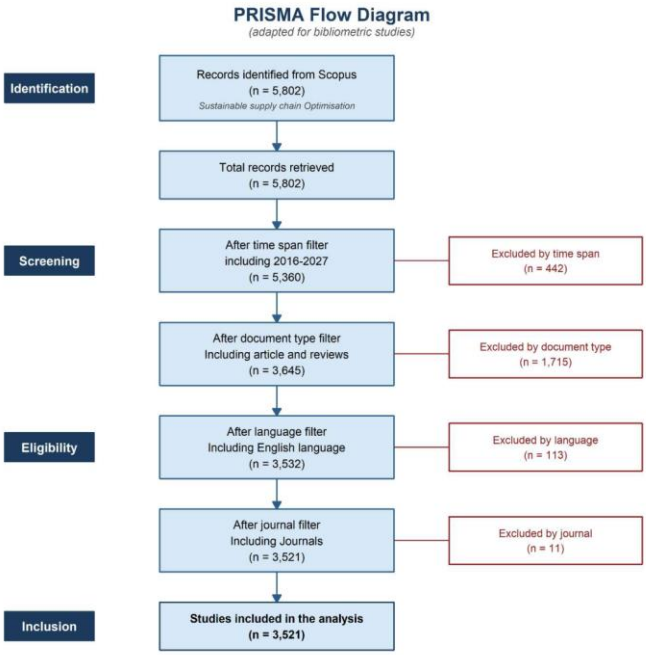


Figure -1: PRISMA flow diagram

3. LITERATURE REVIEW

3.1 Conceptual Background

Sustainable supply chain optimization is about making practical supply chain decisions while considering their costs and wider effects. In operations research, these decisions are expressed as models with objectives, constraints, and possible solutions. A model might choose warehouse locations, production quantities or delivery routes while trying to reduce costs and carbon emissions. The main challenge is that improving one outcome can make another worse. Reviews of multi-objective optimization describe this trade-off as a central feature of sustainable supply chain problems (Jayarathna et al., 2021; Kumar & Kumar, 2025).

Deciding what a model should measure is where the triple bottom line comes in. Cost and service level cover the economic side, while fuel use, emissions and discarded material cover the environmental side. The social side is harder, since employee welfare and the effect on neighbouring communities do not convert easily into numbers, a difficulty that Messmann et al. (2020) take up directly. A model that tracks cost and emissions but ignores people may produce sound results and still say little about sustainability in its full sense.

Returning goods through the chain raises similar problems. Collecting used products for repair, recovery or recycling needs vehicles, handling centres and processing capacity, and none of that is free. Lozano-Oviedo et al. (2024) review how closed-loop networks have been modelled, and Langenaeker et al. (2026) look at circular supply chains by breaking them into their component processes.

Read together, the two studies suggest that recovery has to be planned as part of the network, not bolted on as a separate green project. This review therefore concentrates on how OR methods handle such decisions when objectives conflict, information is incomplete and operations are disrupted.

A few technical terms recur throughout the studies discussed, so they are defined here first:

Table -1: Definitions of key terms

Term	Definition
Multi-objective optimisation	Weighing two or more goals together, where gains on one may come at the expense of another.
Pareto optimality	A state in which no objective can be improved without making at least one other worse.
Robust optimisation	Choosing decisions that still work across a range of uncertain conditions.
Metaheuristic optimisation	A search strategy for hard problems that finds good solutions without guaranteeing the best one.
Fuzzy optimisation	A way of building vague or imprecise information into a model.
Closed-loop supply chain	A network that carries forward deliveries and also returns products for reuse or recovery.
Life-cycle assessment (LCA)	Assessing environmental impacts across every stage of a product's or process's life.
Carbon abatement	Measures taken to cut greenhouse-gas emissions.

3.2 Evidence from Literature

What a model should optimise is a question that runs through much of this work. Jayarathna et al. (2021) discuss multi-objective approaches in sustainable supply chains and logistics, and Kumar and Kumar (2025) surveyed a wider range of optimisation models. The two reviews complement each other, and both make clear that adding more objectives is only the first step. Lower emissions can raise costs, and better delivery reliability may need spare capacity. A decision-maker is therefore better served by seeing the feasible trade-offs than by receiving one answer labelled 'optimal'. An organisation can usually do more with a set of alternatives than with a single headline improvement.

Where the decision gets made is a second question. Madani et al. (2024) study sustainable network design in which OR methods help to choose facilities and set the flows between them. Such choices are not easily reversed once warehouses, or processing sites exist. Inventory is a different matter, because orders recur, demand shifts and unsold stock can turn into waste. Becerra et al. (2021) review green inventory models, while Salas-Navarro et al. (2026) examine vendor-managed inventory in sustainable contexts. Set next to each other, these studies show something easy to miss: a well-designed network can still fall short if its replenishment rules lead to frequent deliveries, stock-outs or surplus. Long-term and day-to-day optimisation needs to work together.

Supply chains also run on information that is never wholly certain. Suppliers fail, demand jumps without notice and transport links close. Safari et al. (2024) apply a scenario-based robust approach to resilient and sustainable network decisions, and Goli et al. (2025) build a robust network model for a technology-enabled scenario. Each study deals with the weakness of planning only for ordinary conditions, though neither removes uncertainty from the picture. Robustness has a price: a protected solution can cost more in normal times. Whether that price is worth paying depends on how severe the disruptions might be and how much loss the organisation can absorb.

Modelling uncertainty is one thing; gathering the information needed to model it is another. Scenario-based methods depend on credible descriptions of what to expect, and probabilistic approaches need a basis for estimating likelihoods. When these inputs are largely guessed, even a sophisticated result can be fragile. Running the same decision through several plausible conditions often says more than a precise figure resting on a single forecast. An OR model should therefore keep its assumptions visible instead of burying them under a complex solution method. Problem size limits which methods are viable. Facility choices, shipment quantities, and routes combine far more possibilities than anyone can check one by one. Faramarzi-Oghani et al. (2023) . Metaheuristics for sustainable supply chains, and Xiao et al. (2025) discuss recent developments in related optimisation algorithms. When exact search becomes impractical, these techniques can still yield workable solutions. A good result on one set of data, though, says little about performance on another. Algorithm studies would be more convincing if they tried different problem sizes, compared against simpler methods and showed how much results varied from run to run.

Circularity tests whether models capture the whole problem. Recycling can reduce the demand for new materials, yet collecting and processing returns uses resources of its own. Lozano-Oviedo et al. (2024) address optimisation of closed-loop networks, while Li et al. (2026) review research on carbon pricing and cap policies. That policy angle is crucial, since a carbon charge can change which route, facility or recovery option looks economical. Langenaeker et al. (2026) also stress the processes inside circular systems. Between them, these studies indicate that whether recovery pays off depends on network design, the cost of reverse flows and the environmental rules in force.

Biomass networks show how hard it is to separate these factors. Agricultural residues are scattered across locations, their availability shifts with the seasons, and moving bulky material is expensive. Luna-del Risco et al. (2026) review bioenergy supply chains in Latin America, covering optimisation and the circular use of residues. A model focused only on the processing plant could overlook collection and transport effects here. Counting emissions at just one stage can also make an option look cleaner than it is over its whole journey.

Other studies support decisions through evaluation rather than by choosing routes or production levels directly. Paul et al. (2021) review multi-criteria decision-making methods, which allow options to be compared on several measures. Marques and Santos (2025) look at how business intelligence and OR connect, and Guzmán et al. (2026) develop an approach combining a digital twin with reinforcement learning for circular supply chains. These tools do different jobs. One ranks alternatives, another turns raw data into usable information, and the third supports decisions that change over time.

Balancing resilience against efficiency is particularly hard. A second supplier or some spare capacity protects operations but raises everyday running costs. Yuniarti and Arvitrida (2025) review sustainable and resilient supply chain network design, treating the two concerns together, and their emphasis offers a useful counterweight to models that count idle capacity purely as waste. A network that looks best under stable conditions can turn out to be the costliest when disruption hits. For that reason, results should be compared under stress and not only under the average conditions used to build the model.

Across these areas, the strongest contributions are not necessarily the ones with the most variables or the newest algorithm. What sets them apart is that they explain the decision problem, say what sustainability means in their setting and show what happens when a major assumption changes. Inventory models and facility-location models, for instance, both bear on emissions but answer different questions. Likewise, an optimisation study of recycling does not prove that every recycling network lowers overall impact. Moving from one model's findings to broader conclusions calls for care.

3.3 Research Gaps

The first gap lies in how social outcomes enter OR models. Costs and emissions already have standard units, whereas safety, job quality and community effects are harder to measure fairly. Messmann et al. (2020) point out how difficult social impacts are to quantify, and Kumar and Kumar (2025) show why sustainability objectives need more even coverage. Future studies could try a small set of transparent social measures and state whose interest those measures stand for. If not, social sustainability may appear in the introduction and never reach the optimised solution.

Circularity and disruption also deserve to be studied in one operational setting. Lozano-Oviedo et al. (2024), Langenaeker et al. (2026) and Yuniarti and Arvitrida (2025) come at recovery networks and resilience from different directions. What happens to collection, reuse and remanufacturing when suppliers or transport links fail is still worth investigating. The key question is whether a network can keep useful recovery going during a disruption without unacceptable costs or emissions.

Third, models need to be checked more thoroughly against practical conditions. The algorithm reviews by Faramarzi-Oghani et al. (2023) and Xiao et al. (2025) show how many computational approaches exist, but a solution's value also rests on data quality, scale and repeatability. Newer techniques could be compared with transparent baseline models, with unfavourable test cases reported alongside favourable ones, and recommendations could be tested against changes in demand, policy or carbon prices. A firm is unlikely to trust a complex method when it cannot tell when the method might fail.

The literature points to a simple conclusion: sustainable supply chain optimisation depends less on finding one universal method than on modelling the right trade-offs for the right setting. OR can compare cost, emissions, recovery and reliability, yet its conclusions hinge on which impacts are counted and how uncertainty is treated. One promising direction links social measure with circular-flow and disruption decisions, then tests such models on realistic operational data. That would bring mathematics closer to the decisions organisations actually face.

4. RESEARCH OBJECTIVES

Bibliometric reviews usually pair a performance analysis of a field with a mapping of its structure (Donthu et al., 2021; Zupic & Čater, 2015). In line with this approach, the study pursues three research objectives:

RO1: To examine the publication, source and citation trends of research on the application of operations research in sustainable supply chain optimisation between 2016 and 2027.

RO2: To identify the leading authors, journals, influential documents and thematic clusters that shape the intellectual structure of the field.

RO3: To develop a future research agenda by identifying the gaps in the existing literature and the directions in which the field should move.

5. DATA ANALYSIS AND RESULTS

5.1 Introduction and Data

This report looks at 3,521 Scopus records on sustainable supply chain optimisation, exported on 10 September 2026. The records run from 2016 to 2027. Of these, 3,095 are journal articles (87.9%) and 426 are reviews (12.1%), and everything is in English. They come from 968 sources and list roughly 9,677 different author names. Biblioshiny produced the figures for annual output, sources, average citations, the thematic map and the summary panel. The rest of the numbers (citations, authors and keywords) come from a script we wrote to read the RIS and BibTeX files.

Biblioshiny counts 3,519 documents, 966 sources and 9,693 authors, which is a little different from the 3,521, 968 and 9,677 we get from the files directly. The gap is probably down to duplicate or incomplete entries, since the RIS file has one repeated DOI and two repeated titles. When the two sources disagree, we say which one we used. There are also two things we could not do. The export has not cited-reference lists (Biblioshiny shows 0 references), so co-citation and bibliographic coupling were out. We also did not have VOSviewer maps for this dataset, so keywords are covered through frequency counts and the Biblioshiny thematic map.



Figure -2: Main information summary for the dataset (Biblioshiny).

The summary panel gives an average of 4 co-authors per document, 154 authors with single-authored documents and an international co-authorship rate of 35.64%. The average document age is 2.68 years, so most of this literature is quite recent, and the average is 24.93 citations per document.

5.2 Publication Trend

Output has climbed almost every year. There are 77 papers from 2016, 107 from 2017, 116 from 2018 and 142 from 2019. After that the counts are 187 (2020), 199 (2021), 257 (2022) and 300 (2023). Growth then speeds up: 467 papers in 2024, which is 55.7% more than 2023, and 803 in 2025, up another 71.9%. The 2026 figure of 859 is already the highest in the file, even though the exports were taken in September, so the full year will most likely end higher still. Seven more records are dated 2027; these are articles in press.

Before 2020 there are 442 papers (12.6% of the dataset). From 2020 to 2026 there are 3,072 (87.2%). Papers from 2025 and 2026 alone add up to 1,662, nearly half (47.2%) of everything we have. Over the full years from 2016 to 2025, output grew by about 29.8% a year on a compound basis.

The annual growth rate that Biblioshiny reports, −19.59%, should not be taken at face value. It is worked out from the first and last year in the data, so it compares 77 papers in 2016 with 7 papers in 2027 over 11 years. Those 7 are just in-press records, and 2026 is not a complete year either. The steep drop at the right-hand end of Figure 3 therefore comes from how the data were exported, not from the field shrinking. Looking only at complete years, research on this topic is still growing fast in-press records only.

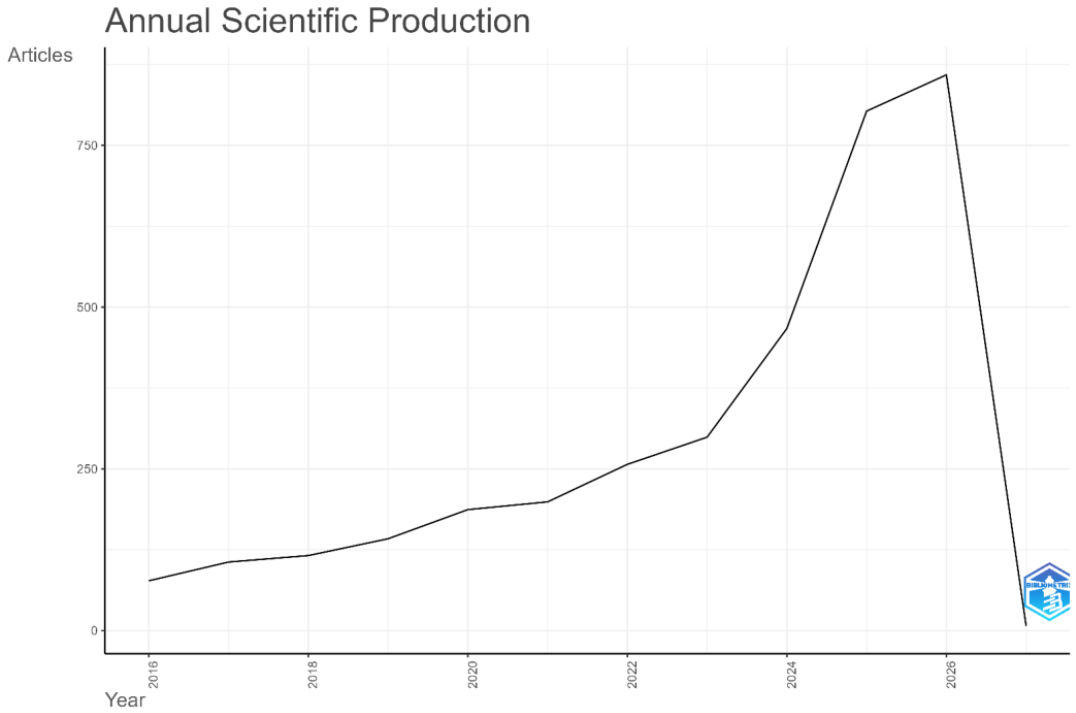


Figure -3: Annual scientific production, 2016–2027 (Biblioshiny). The 2026 value is a partial year and 2027 contains

5.3 Where the Research Is Published

The 3,521 records are spread across 968 sources, and 578 of them (59.7%) published only one paper in the dataset. Even so, a handful of journals account for a big share. Sustainability (Switzerland) is first with 234 papers, and the Journal of Cleaner Production is a close second with 222. Next come Computers and Industrial Engineering (104), Process Integration and Optimization for Sustainability (63) and Computers and Chemical Engineering (56). These five journals hold 679 papers between them, or 19.3% of the dataset, and the top ten hold 911 (25.9%). Environment, Development and Sustainability and the International Journal of Production Research have 50 each, followed by Applied Energy (48), Annals of Operations Research (45) and Energies (39).

The list of sources is wider than you might expect for a supply chain topic. Sustainability and cleaner-production journals lead, and operations research and industrial engineering titles follow. There is also a clear group of energy and chemical engineering venues, including Applied Energy, Energies,

Computers and Chemical Engineering and Process Integration and Optimization for Sustainability. That suggests supply chain optimisation work is closely tied to process engineering and energy planning.

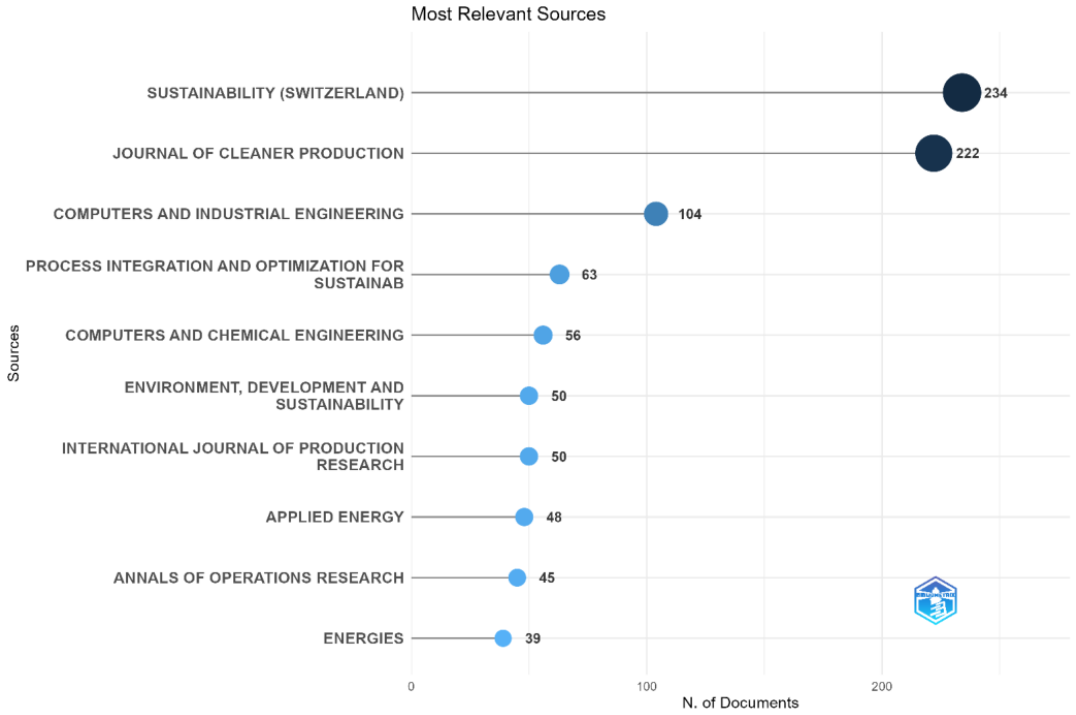


Figure -4: Top 10 sources by number of documents (Biblioshiny).

5.4 Citation Patterns

Together the records have 87,756 citations. Scopus leaves out the cited-by field when a paper has no citations, so 2,882 records (81.9%) show at least one citation, and the other 639 (18.1%) are counted as uncited. The mean is 24.9 citations per paper, but the median is only 8, so a few highly cited papers pull the average up. The ten most-cited papers hold 5.8% of all citations, the top 1% (35 papers) holds 13.4%, and the top 10% (352 papers) holds 53.4%. There are 186 papers with 100 citations or more.

The most-cited paper is a 2018 review of circular economy theories and implementation tools, with 1,184 citations (Kalmykova et al., 2018), published in Resources, Conservation and Recycling. Second is a 2017 framework for sustainable supplier selection in the Journal of Cleaner Production with 764 (Luthra et al., 2017). Third is a 2018 overview of the energy demand and environmental impact of additive manufacturing with 471 (Peng et al., 2018). Fourth is a 2022 study of Industry 5.0 research trends with 455 (Akundi et al., 2022), and fifth is a 2018 operations research perspective on sustainable supply chains from the European Journal of Operational Research with 398 (Barbosa-Póvoa et al., 2018). The Industry 5.0 paper earned its citations in only four years, which makes it the best example of a recent paper reaching the top of the list. Reviews also do better than articles: the 426 reviews average 35.9 citations, compared with 23.4 for the 3,095 articles.

Total citations by publication year stay fairly level from 2018 to 2024, between about 9,000 and 10,700 a year, with 2020 the highest at 10,700. Over the same years the number of papers published was more than quadrupled. This means the average per paper keeps falling: 81.7 for 2018 papers, 36.9 for 2022, 20.5 for 2018 papers, 36.9 for 2022, 20.5 for 2024 and 9.1 for 2025. Papers from 2026 average 1.5 and the 2027 records have none yet. Recent papers just have not had time to be cited, so the fall after 2023 is mostly citation lag.

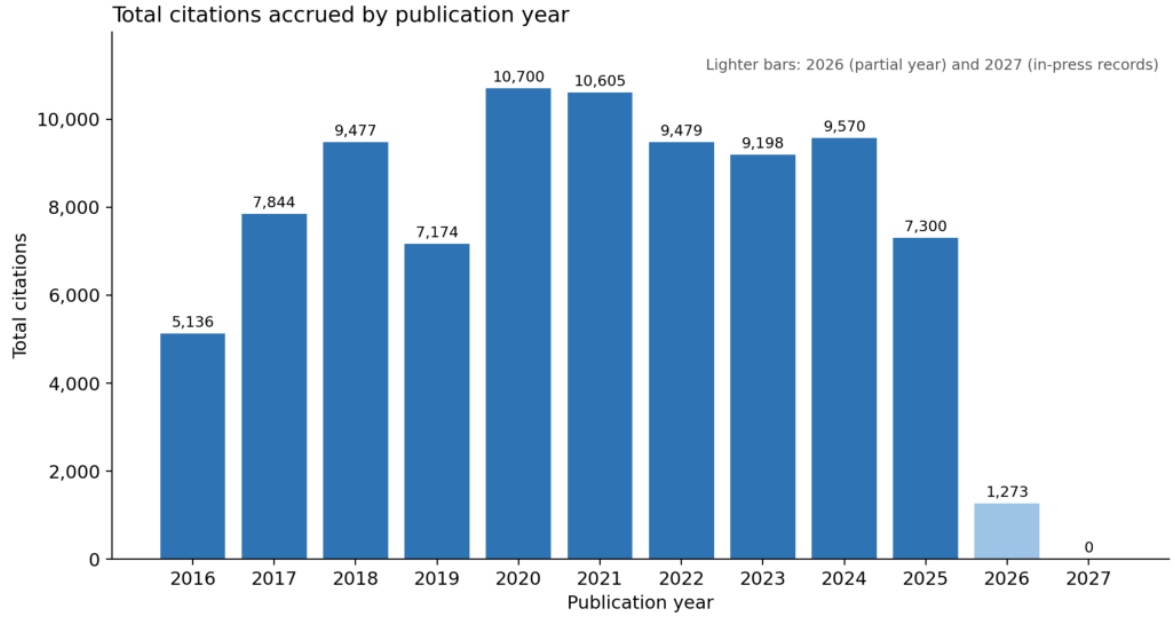


Figure -5: Total citations accrued by publication year (author's analysis of RIS metadata).

The Biblioshiny chart of average citations per year shows the same pattern per paper. Reading values off the chart, they sit at roughly 6 to 9 from 2016 to 2023, with highs around 2018 and 2021 and a dip in 2019. After that they fall quickly for the newest years.

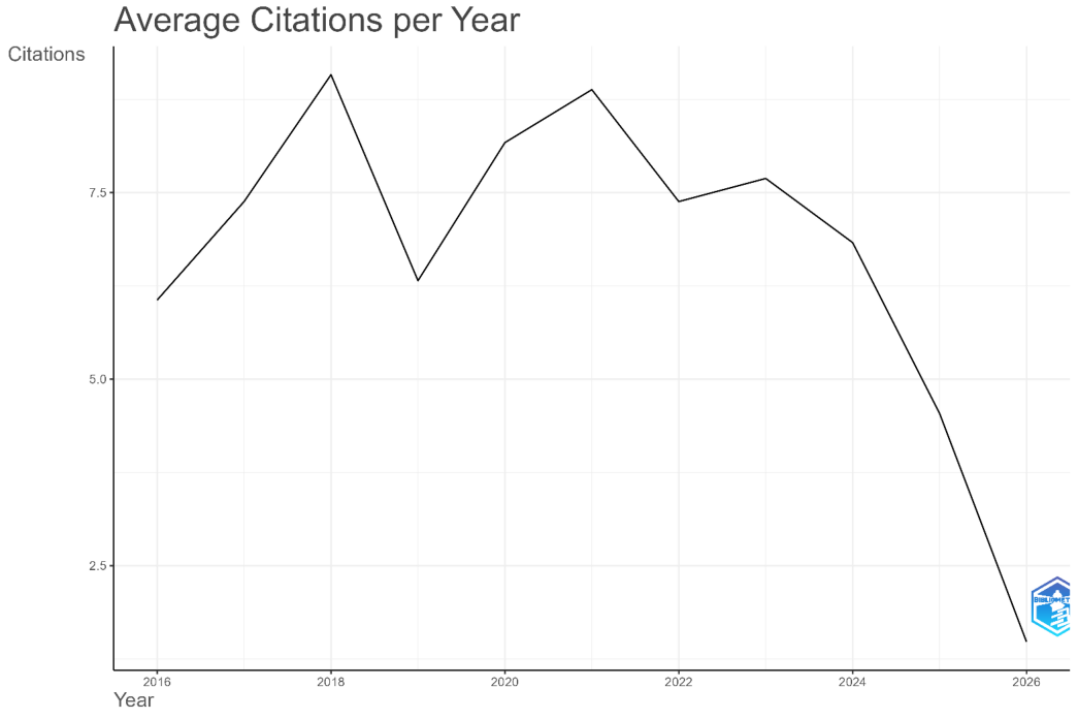


Figure -6: Average citations per year by publication year (Biblioshiny).

5.5 Author Productivity

No one author dominates this dataset. The files contain about 9,677 different author names. Of these, 7,935 (82.0%) appear on a single paper and 8,921 (92.2%) on two or fewer. The average paper has 4.0 authors, 172 papers have a single author, and Biblioshiny puts international co-authorship at 35.64%.

Author counts need some care. The RIS file gives each author as a surname plus initials, and the most frequent names there are Zhang, Y. (41 papers), Wang, Y. (39), Wang, X. (36) and Liu, Y. (35). These are almost certainly several different researchers sharing the same name form, so they cannot be read as real productivity figures. The BibTeX file includes full first names, which separates many of them. By those names, Biswajit Sarkar is first with 30 papers. Anand Chauhan and José María Ponce-Ortega follow with 24 each, then Reza Tavakkoli-Moghaddam with 22, and Mir Saman Pishvaee and Kannan Govindan with 20 each. Erfan Babaee Tirkolaee has 18, and Hadi Sahebi and Alireza Goli have 16 each. Full names can still merge with different people, and the export has no Scopus author IDs, so these numbers are only a rough guide. Since most authors appear once or twice, the field looks like a large and active community and not a small, closed group.

5.6 Keyword Analysis

Author keywords are available for 3,370 of the 3,521 records (95.7%), covering about 9,279 different terms once we lower-cased everything and merged the British and American spellings of "optimisation". Figure 7 leaves out the three main search terms,

"sustainability" (603 records), "supply chain" (244) and "supply chain management" (206), because they describe the whole dataset and do not tell us anything about its parts.

Among the remaining terms, optimisation language is the most common. "Optimization" (308) and "multi-objective optimization" (271) are at the top, followed by "supply chain optimization" (109), "robust optimization" (104) and "uncertainty" (82). Together they point to a literature built on mathematical models and decisions made under uncertainty. Circular economy (216) is the biggest sustainability theme, ahead of "sustainable supply chain" (165), "sustainable development" (114), "closed-loop supply chain" (108) and "life cycle assessment" (77). Data-driven methods also rank high, with "artificial intelligence" (127) and "machine learning" (112) both in the top ten, above "blockchain" (66), "industry 4.0" (66) and "resilience" (65). Output grew most steeply after 2023, at the same time as AI and machine learning keywords became prominent, so the two may be linked. Keyword counts alone cannot prove that, though metadata)

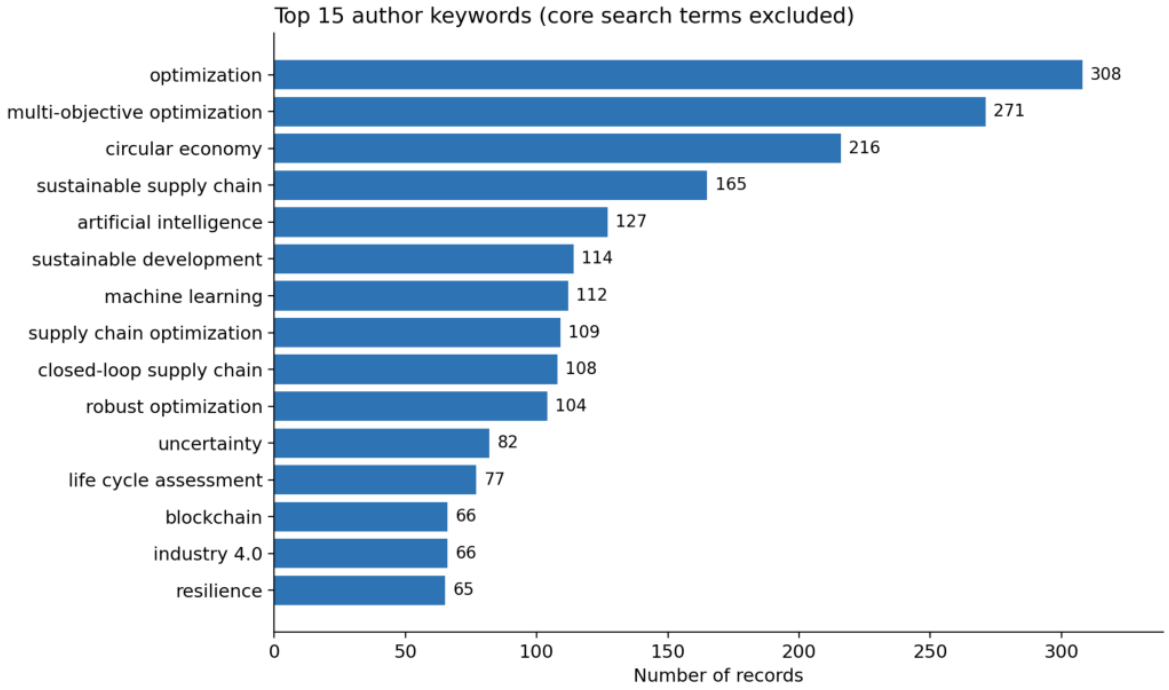


Figure -7: Top 15 author keywords by frequency, excluding core search terms (author's analysis of BibTeX

5.7 Thematic Structure (Biblioshiny)

The Biblioshiny thematic map shows how the keyword clusters are positioned strategically, which the frequency counts cannot do.

5.7.1 Strategic (Centrality–Density) Map

Each cluster is plotted by centrality, meaning how connected it is to the rest of the field, and by density, meaning how well developed it is internally. Two clusters fall in the upper-right motor-theme quadrant, which means they are both central and well developed. One is circular economy, artificial intelligence and machine learning, which has the highest density on the whole map. The other is sustainability, multi-objective optimisation and closed-loop supply chain, which sits just above the density line and to the right of the centrality line. Taken together they look like the working core of the field: sustainability-driven multi-objective models and, increasingly, AI-based methods.

A cluster of optimization, supply chain and life cycle assessment lies in the lower-left quadrant (emerging or declining themes), fairly close to the centre. The most marginal cluster, in the far lower-left corner, groups supply chain management, sustainable supply chain and green supply chain. These are the broadest terms in the dataset. Their weak position probably happens because almost every record uses them, so they do not form a tight cluster of their own. It does not necessarily mean the topics are fading. No cluster is labelled in the niche or basic-theme quadrants, although the Biblioshiny logo partly covers the lower-right corner.

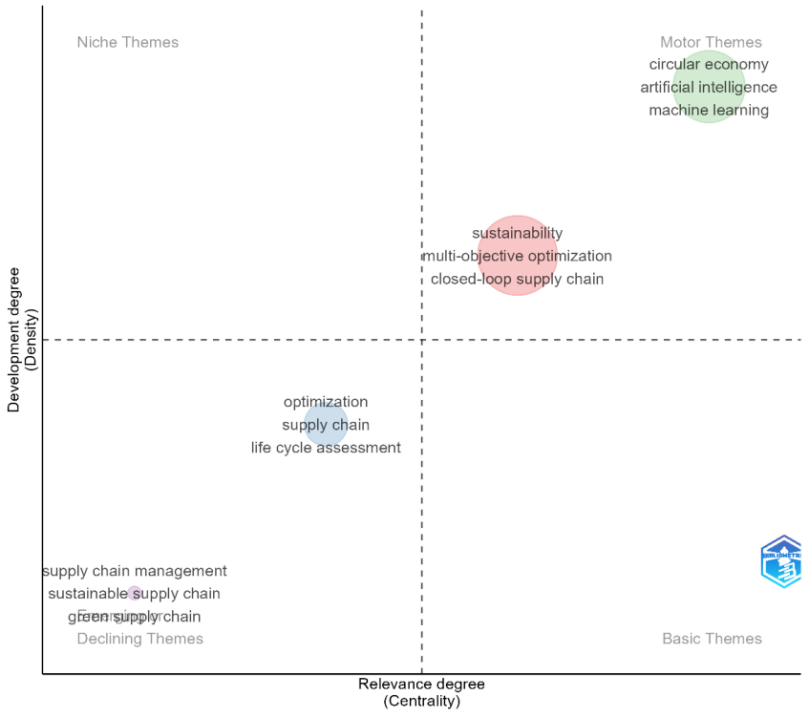


Figure -8: Strategic (centrality–density) map of thematic clusters (Biblioshiny).

5.8 Supplementary Notes and Limitations

A few points should be kept in mind when reading the results above:

- **Partial years:** the export was made on 10 September 2026, so 2026 is incomplete and the seven 2027 records are articles in press. We kept both in the counts. The −19.59% growth rate from Biblioshiny comes from these end years.
- **Author names:** the RIS file gives surnames with initials, which merges people with the same name. The BibTeX file has full first names but no author IDs, so author counts are approximate.
- **Citations:** Scopus leaves out the cited-by field for uncited papers, so records without it are counted as zero. The totals are Scopus counts at the export date.
- **No cited references or VOSviewer maps:** co-citation, bibliographic coupling and VOSviewer network, density and overlay views were not part of this analysis.
- **Document types:** the dataset has only articles and reviews, so conference papers, book chapters and editorials are not included.

6. DISCUSSION AND IMPLICATIONS

6.1 Future Research Agenda

This agenda is built from a bibliometric analysis of 3,521 Scopus records (2016–2027) on operations research applications in sustainable supply chain optimisation. The field has grown fast — from 77 papers in 2016 to more than 800 a year by 2025 — and almost half of the entire dataset was published in just the last two years. That scale brings its own problems. A literature this large and this recent is naturally uneven: citation patterns are skewed, the data itself has structural limits, and some of its most prominent themes are prominent in the keyword counts without yet being proven in practice. The sections below set out six such problem areas, drawing on the thematic, citation, and authorship patterns in the dataset, and close with a consolidated set of recommendations.

6.2 Citation Concentration and Lag Distort What Looks Important

Citations in this dataset are extremely skewed: the top 10% of papers (352 of 3,521) hold 53.4% of all citations, while the median paper has only 8. The most-cited work is Kalmykova, Sadagopan, and Rosado (2018), a review of circular economy theories and implementation tools, followed by Luthra, Govindan, Kannan, Mangla, and Garg (2017) on sustainable supplier selection, and Peng, Kellens, Tang, Chen, and Chen (2018) on the energy footprint of additive manufacturing. These papers, together with Barbosa-Póvoa, da Silva, and Carvalho's (2018) operations-research perspective on sustainable supply chains, anchor the field's most-cited core, but they are all from 2017–2018. Because nearly half of the dataset was published after 2023, average citations per paper fall sharply for recent years: from 81.7 for 2018 papers to 20.5 for 2024 and just 1.5 for 2026. Akundi et al.'s (2022) work on Industry 5.0 trends is the clear exception, reaching 455 citations in only four years, which shows fast recognition is possible but rare. The risk is that citation-based judgements of "what matters" in this field systematically undervalue 2023–2026 work, including most of the AI- and machine-learning-related literature, simply because it has not had time to accumulate citations.

Future reviews of this literature should use time-normalised or field-normalised citation metrics rather than raw counts, track usage or download data as an interim signal for recent work, and periodically re-run this kind of analysis as citation lag resolves, rather than treating the 2017–2018 citation leaders as a permanent core.

6.3 The Underlying Data Limits: How Well the Field's Structure Can Be Mapped

The dataset itself constrains the conclusions that can be drawn from it. The Scopus export carries no cited-reference lists, so co-citation and bibliographic coupling — the standard tools for mapping how papers intellectually relate to one another — could not be run, and no VOSviewer network, density, or overlay views were produced. Author identity is also only approximate: the RIS file records surnames with initials only, so names such as Zhang, Y. (41 papers) or Wang, Y. (39) almost certainly merge several distinct researchers, and even the fuller BibTeX names used to identify leading contributors — Biswajit Sarkar, Anand Chauhan, José María Ponce-Ortega, Reza Tavakkoli-Moghaddam, Mir Saman Pishvaee, Kannan Govindan, Erfan Babaee Tirkolaee, Hadi Sahebi, and Alireza Goli — come with no Scopus author IDs to confirm them.

This matters because every claim this report makes about authorship concentration, or about which clusters are structurally central, rests on approximations rather than confirmed identity and reference data. Future bibliometric work on this field should use exports that retain full cited-reference lists and, where possible, ORCID-linked author identifiers, so that co-citation mapping and productivity rankings can be stated with real confidence rather than treated as a rough guide.

6.4 The Circular-Economy, AI Cluster Is Prominent, Not Yet Proven

The thematic map's single densest and most central cluster combines circular economy, artificial intelligence, and machine learning. The keyword counts support this: "artificial intelligence" (127) and "machine learning" (112) both sit in the top ten terms, and their rise coincides with the steepest period of output growth, 467 papers in 2024 and 803 in 2025. It is tempting to read this as evidence that AI methods are transforming sustainable supply chain optimisation, but the report is explicit that a keyword co-occurrence spike is not proof of a causal link, and the same growth period could just as easily reflect a wave of conceptual papers using AI terminology without delivering tested methods.

The research gap this leaves is a validation gap, not a visibility gap. Future work should test what AI and machine-learning methods actually add beyond the established multi-objective and robust-optimisation baselines that already dominate the keyword list ("multi-objective optimization," 271 mentions; "robust optimization," 104), through direct comparative studies rather than parallel but separate literatures. It would also be worth revisiting this cluster's position on the strategic map once the 2024–2026 papers have had time to accumulate citations, to see whether its current centrality and density hold up or were partly an artefact of sheer publication volume.

6.5 The Field's Broadest Terms Sit Apart From Its Technical Core

The strategic map places "supply chain management," "sustainable supply chain," and "green supply chain" the field's broadest, most foundational terms, in the most marginal position on the map, while the technical core of optimisation, robust optimisation, and uncertainty modelling sits elsewhere. The report attributes this to the terms being used almost universally, so they never form a tight cluster of their own; but structurally, it also means the field's governing vocabulary and its technical methods are not binding closely together even as the literature has grown tenfold since 2016. This echoes a pattern seen in smaller studies of this field: management- and framework-oriented work and quantitative, model-based work tend to run in parallel rather than feeding into one another directly. Closing this gap is less about new empirical studies and more about synthesis: future systematic reviews should deliberately map optimisation techniques back onto supply chain management theory and governance frameworks, rather than treating "supply chain management" as background context that every paper cites but few papers build on directly.

6.6 Energy and Process-Engineering Convergence Is Visible Only Through Journals, Not Themes

A striking feature of where this literature is published is its overlap with energy systems and process engineering: Applied Energy (48 papers), Energies (39), Computers and Chemical Engineering (56), and Process Integration and Optimization for Sustainability (63) are all among the most active venues. That is a real and sizeable convergence, these four journals alone account for more papers than most dedicated supply chain titles but it does not appear as its own cluster on the Biblioshiny thematic map, which organises the field by author keywords rather than publication venue. The result is a convergence that is happening in practice but has not yet been explicitly synthesised in the literature.

Future research would benefit from a dedicated review connecting supply chain optimisation methods directly to process-integration and energy-system planning, treating this as a distinct line of work rather than something visible only indirectly, through where papers happen to be published.

6.7 Scale Without Coordination

With roughly 9,677 distinct author names, 82% appearing on only one paper, and an average of four co-authors per document, this is a large and genuinely open research community rather than one anchored by a small core, as is sometimes seen in more mature fields. Even the most productive identifiable author, Biswajit Sarkar, accounts for only 30 of 3,521 papers under 1% of total output. International co-authorship stands at 35.64%, which is healthy but still leaves most work produced within single-country teams.

The risk in a field this dispersed is duplicated effort: many researchers independently formulating similar multi-objective or robust-optimisation models for closely related problems, without a shared infrastructure to prevent overlap. Future work should prioritise coordinated, multi-author consortia and shared open datasets or model repositories, so that the field's considerable size translates into cumulative knowledge-building rather than parallel, disconnected contributions.

The problems identified here are not about a shortage of activity — output has grown nearly thirtyfold since 2016 but about how well that activity is being turned into reliable, cumulative knowledge. Citation patterns currently favour older work over the recent surge of AI- and circular-economy-themed papers; the data available for this kind of analysis has real structural limits; and several of the field's most visible themes are visible through keyword frequency and journal choice rather than through tested, synthesised evidence. A future research agenda built around resolving these specific gaps rather than simply adding to an already fast-growing literature — would do more to move the field from a large body of work into a genuinely well-understood one.

6.8 Recommendations for Future Research

- Use time- or field-normalised citation metrics, and periodically repeat this analysis, so that 2023–2026 work is not undervalued simply because it has not had time to accumulate raw citations.
- Re-run this kind of study on an export that retains full cited-reference lists and ORCID-linked author identifiers, enabling proper co-citation mapping and reliable productivity rankings.
- Run direct comparative studies testing AI and machine-learning methods against established multi-objective and robust-optimisation baselines, rather than treating the circular-economy–AI cluster's prominence as evidence of its effectiveness.
- Produce systematic reviews that explicitly connect supply chain management theory and governance frameworks to the field's technical optimisation methods, rather than leaving them as parallel literatures.
- Commission a dedicated review synthesising supply chain optimisation with process-integration and energy-system planning, given the strong but currently venue-only overlap between these areas.
- Encourage coordinated, multi-author consortia and shared open datasets or model repositories to reduce duplicated modelling effort across this large, dispersed research community.

7. CONCLUSION AND LIMITATIONS

This study sets out to map the application of OR in sustainable supply chain optimisation through a bibliometric analysis of 3,521 Scopus records, and its three research objectives have largely been met. For the first objective, the trend analysis shows output rising from 77 papers in 2016 to 803 in 2025, a compound growth of about 29.8% a year over the complete years from 2016 to 2025, with citations concentrated in a small group of older papers and recent work still affected by citation lag. For the second, the leading journals, influential documents, keyword themes and the strategic map of thematic clusters were identified, although the absence of cited-reference lists and unique author identifiers meant that co-citation analysis and precise author rankings could not be produced, so this objective is met in part. For the third, the findings were turned into a six-part research agenda. These outcomes follow the performance-analysis and science-mapping logic recommended for bibliometric studies (Donthu et al., 2021; Aria & Cuccurullo, 2017).

Taken together, the results describe a field that is large, young and open. Optimisation language, led by multi-objective and robust optimisation, forms the long-standing technical core, tied to circular economy, closed-loop supply chains and life cycle assessment, while Artificial intelligence and machine learning now sit in the most central and densest part of the thematic map. Early citation leaders, such as the circular economy review by (Kalmykova et al. 2018) and the OR perspective of (Barbosa-Póvoa et al. 2018), still anchor the field, yet the rapid recognition of Akundi et al. (2022) shows that newer topics can gain influence quickly. At the same time, prominence in keyword counts should not be mistaken for demonstrated effectiveness, because the link between the growth in output and the rise of AI terminology cannot be established from keyword frequencies alone.

7.1 Academic Implications

The study contributes to the academic literature in three ways. First, where earlier reviews examine one method or one problem class at a time (Jayarathna et al., 2021; Lozano-Oviedo et al., 2024), it offers a field-wide, quantified picture of the OR and sustainable supply chain literature from 2016 to 2027, and so extends the quantitative-modelling reviews of Brandenburg et al. (2014) to the most recent and fastest-growing period.

Second, it shows how raw citation counts can misrepresent a young literature, which supports the use of time-normalised metrics in future reviews. Third, it identifies a validation gap for AI-based methods and a separation between management frameworks and technical models, which give researchers specific and testable directions in place of a general call for more work.

7.2 Practical Implications

For practitioners and policymakers, the literature points to several lessons. Decision-makers are better served by models that show the feasible trade-offs between cost, emissions and service than by a single answer labelled optimal (Jayarathna et al., 2021). Robust and scenario-based models, such as the one developed by Safari et al. (2024), protect a network against supply disruption, but that protection can raise costs under normal conditions, so the level of protection should be weighed against the losses an organisation can absorb. Policy settings matter as well, because a carbon price or cap can change which route, facility or recovery option is the economical one (Li et al., 2026). Firms considering AI-enabled optimisation should ask for comparisons with simpler baseline models before adopting it at scale.

7.3 Limitations

Several limitations qualify these findings. The data come from a single database, Scopus, and are restricted to English-language journal articles and reviews, so conference papers, book chapters and other databases are not represented (Donthu et al., 2021). The export contained no cited-reference lists, which ruled out co-citation and bibliographic coupling, and author names were recorded as surnames with initials, so author counts are approximate. The 2026 records are incomplete because the export was taken in September 2026, the 2027 records are articles in press, and recent papers have had little time to accumulate citations, which affects every citation-based comparison. Finally, bibliometric methods describe patterns in publications and not the quality or findings of individual studies (Zupic & Čater, 2015).

7.4 Future Research Directions

Future work can address these limits and the gaps in the agenda. Studies built on exports with full cited reference lists and ORCID-linked author identifiers would allow co-citation mapping and reliable productivity rankings and repeating the analysis once the 2024–2026 papers have matured would show whether the current prominence of the circular economy–AI cluster holds. Primary research could compare AI and machine-learning methods directly with established multi-objective and robust baselines, for example in digital-twin and reinforcement-learning settings for circular supply chains (Guzmán et al., 2026) and could bring social

measures into optimisation models alongside cost and emissions (Messmann et al., 2020). By addressing these gaps, OR research on sustainable supply chains can move from a large body of work to a well-understood and cumulative one.

REFERENCES

[1] Akundi, A., Euresti, D., Luna, S., Ankobiah, W., Lopes, A., & Edinbarough, I. (2022). State of Industry 5.0—Analysis and identification of current research trends. Applied System Innovation, 5(1), 27. https://doi.org/10.3390/asi5010027

[2] Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics, 11(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007

[3] Barbosa-Póvoa, A. P., da Silva, C., & Carvalho, A. (2018). Opportunities and challenges in sustainable supply chain: An operations research perspective. European Journal of Operational Research, 268(2), 399–431. https://doi.org/10.1016/j.ejor.2017.10.036

[4] Becerra, P., Mula, J., Sanchis, R. (2021). Green supply chain quantitative models for sustainable inventory management: A review. Journal of Cleaner Production, 328, 129544. https://doi.org/10.1016/j.jclepro.2021.129544

[5] Boston Consulting Group, & CDP. (2024). Scope 3 upstream: Big challenges, simple remedies. CDP. https://www.cdp.net/press-releases/corporates-supply-chain-scope-3-emissions-are-26-times-higher-than-their-operational-emissions

[6] Bové, A.-T., & Swartz, S. (2016). Starting at the source: Sustainability in supply chains. McKinsey & Company. https://www.mckinsey.com/business-functions/sustainability/our-insights/starting-at-t he-source-sustainability-in-supply-chains

[7] Brandenburg, M., Govindan, K., Sarkis, J., & Seuring, S. (2014). Quantitative models for sustainable supply chain management: Developments and directions. European Journal of Operational Research, 233(2), 299–312. https://doi.org/10.1016/j.ejor.2013.09.032

[8] Dekker, R., Bloemhof, J., & Mallidis, I. (2012). Operations research for green logistics – An overview of aspects, issues, contributions and challenges. European Journal of Operational Research, 219(3), 671–679. https://doi.org/10.1016/j.ejor.2011.11.010

[9] Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research, 133, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

[10] Fahimnia, B., Sarkis, J., & Davarzani, H. (2015). Green supply chain management: A review and bibliometric analysis. *International Journal of Production Economics, 162*, 101–114. https://doi.org/10.1016/j.ijpe.2015.01.003

[11] Faramarzi-Oghani, S., Dolati Neghabadi, P., Talbi, E.-G., & Tavakkoli-Moghaddam, R. (2023). Meta-heuristics for sustainable supply chain management: A review. International Journal of Production Research, 61(6), 1979–2009. https://doi.org/10.1080/00207543.2022.2045377

[12] Feng, Y., Zhu, Q., & Lai, K.-H. (2017). Corporate social responsibility for supply chain management: A literature review and bibliometric analysis. *Journal of Cleaner Production, 158*, 296–307. https://doi.org/10.1016/j.jclepro.2017.05.018

[13] Goli, A., Babaee Tirkolaee, E., Golmohammadi, A.-M., Atan, Z., Weber, G.-W., Ali, S.S. (2025). A robust optimization model to design an IoT-based sustainable supply chain network with flexibility. Central European Journal of Operations Research, 33(3), 1025–1046. https://doi.org/10.1007/s10100-023-00870-4

[14] Guzmán, E., Andrés, B., & Torres-Polo, M. (2026). A cooperative digital twin–multi-agent reinforcement learning for circular supply chains: Balanced control across production, logistics, and sustainability. Computers and Industrial Engineering, 218, 112044. https://doi.org/10.1016/j.cie.2026.112044

[15] Jayarathna, C.P., Agdas, D., Dawes, L., Yigitcanlar, T. (2021). Multi-objective optimization for sustainable supply chain and logistics: A review. Sustainability (Switzerland), 13(24), 13617. https://doi.org/10.3390/su132413617 Kumar, K., Kumar, A. (2025). Application of Optimization Models in Sustainable Supply Chain Management: A Systematic Review Based on PRISMA Guidelines. Process Integration and Optimization for Sustainability, 9(3), 763–790. https://doi.org/10.1007/s41660-024-00455-x

[16] Kalmykova, Y., Sadagopan, M., & Rosado, L. (2018). Circular economy – From review of theories and practices to development of implementation tools. Resources, Conservation and Recycling, 135, 190–201. https://doi.org/10.1016/j.resconrec.2017.10.034

[17] Langenaeker, A., Nimmegeers, P., & Defryn, C. (2026). Circular supply chain design and optimisation through operations research: A systematic review with a process-based perspective and research priorities. Cleaner Logistics and Supply Chain, 19, 100334. https://doi.org/10.1016/j.clscn.2026.100334

[18] Li, X., Ji, D., Gao, D., Jin, C., Li, W., Tian, X., Sun, S., & Gao, K. (2026). A review of closed-loop supply chain optimization research from carbon pricing and cap policy perspective. International Journal of General Systems, 55(3), 341–366. https://doi.org/10.1080/03081079.2025.2534838

[19] Lozano-Oviedo, J., Cortés, C. E., & Rey, P. A. (2024). Sustainable closed-loop supply chains and their optimization models: A review of the literature. Clean Technologies and Environmental Policy, 26(4), 999–1023. https://doi.org/10.1007/s10098-023-02730-w

[20] Luna-del Risco, M., Gómez-David, C.J., González-Palacio, M., Rocha-Meneses, L., Santos-Ballardo, D.U., Orozco Guillen, E.E., Vanegas-Trujillo, E., Patiño-Agudelo, A.D. (2026). Toward Sustainable Bioenergy Supply Chain Management in Latin America: A Systematic Review of Optimization, Circular Valorisation, Methane Mitigation, and Traceability of Agricultural and Livestock Residues. Resources, 15(8), 100. https://doi.org/10.3390/resources15080100

[21] Luthra, S., Govindan, K., Kannan, D., Mangla, S. K., & Garg, C. P. (2017). An integrated framework for sustainable supplier selection and evaluation in supply chains. Journal of Cleaner Production, 140, 1686–1698. https://doi.org/10.1016/j.jclepro.2016.09.078

[22] Madani, B., Saihi, A., Abdelfatah, A. (2024). A Systematic Review of Sustainable Supply Chain Network Design: Optimization Approaches and Research Trends. Sustainability (Switzerland), 16(8), 3226. https://doi.org/10.3390/su16083226

[23] Marques, R.P., Santos, D. (2025). Integrating Business Intelligence and Operations Research for Sustainable Supply Chain Systems: A Systematic Review. Systems, 13(12), 1111. https://doi.org/10.3390/systems13121111

[24] Messmann, L., Zender, V., Thorenz, A., & Tuma, A. (2020). How to quantify social impacts in strategic supply chain optimization: State of the art. Journal of Cleaner Production, 257, 120459. https://doi.org/10.1016/j.jclepro.2020.120459

[25] Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2010). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *International Journal of Surgery, 8*(5), 336–341. https://doi.org/10.1016/j.ijsu.2010.02.007

[26] Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71

[27] Paul, A., Shukla, N., Paul, S.K., Trianni, A. (2021). Sustainable supply chain management and multi-criteria decision-making methods: A systematic review. Sustainability (Switzerland), 13(13), 7104. https://doi.org/10.3390/su13137104

[28] Paul, J., & Criado, A. R. (2020). The art of writing literature review: What do we know and what do we need to know? *International Business Review, 29*(4), 101717. https://doi.org/10.1016/j.ibusrev.2020.101717

[29] Peng, T., Kellens, K., Tang, R., Chen, C., & Chen, G. (2018). Sustainability of additive manufacturing: An overview on its energy demand and environmental impact. Additive Manufacturing, 21, 694–704. https://doi.org/10.1016/j.addma.2018.04.022

[30] Safari, L., Sadjadi, S. J., & Sobhani, F. M. (2024). Resilient and sustainable supply chain design and planning under supply disruption risk using a multi-objective scenario-based robust optimization model. Environment, Development and Sustainability, 26(11), 27485–27527. https://doi.org/10.1007/s10668-023-03769-x

[31] Salas-Navarro, K., Rojano-Flores, M., Salcedo-Villanueva, V., Cárdenas-Barrón, L.E. (2026). An analytical review of vendor-managed inventory models in sustainable supply chains. Supply Chain Analytics, 13, 100189. https://doi.org/10.1016/j.sca.2025.100189

[32] Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. Journal of Cleaner Production, 16(15), 1699–1710. https://doi.org/10.1016/j.jclepro.2008.04.020

[33] Xiao, Q., Shi, W., Zhang, Y. (2025). A Review of Sustainable Supply Chain Optimization Utilizing Metaheuristic Algorithms: A Comparison from Both Chinese and International Perspectives. Process Integration and Optimization for Sustainability, 9(4), 1199–1227. https://doi.org/10.1007/s41660-025-00516-9

[34] Yuniarti, R., Arvitrida, N.I. (2025). A scoping review and bibliometric analysis of sustainable and resilient supply chain network design. Supply Chain Analytics, 12, 100162. https://doi.org/10.1016/j.sca.2025.100162

[35] Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. Organizational Research Methods, 18(3), 429–472. https://doi.org/10.1177/1094428114562629