

Reverse Logistics Optimization

**Dr Richa Kalpesh Saxena¹, Nami Mehta², Nandini Mulchandani³,
Prachi Kumari⁴, Prakhar Gupta⁵, Preksha Sao⁶**

¹Assistant Professor, Marketing & Operations, NMIMS, Anil Surendra Modi School of Commerce,
Mumbai Campus, India

^{2,3,4,5,6}Bachelors of Business Administration (BBA), NMIMS, Anil Surendra Modi School of Commerce,
Mumbai Campus, India

ABSTRACT:

The present review is a systematic literature review-cum-bibliometric analysis of Reverse Logistics Optimisation to examine the field holistically. The study aims to identify the dominant themes and understand the role of optimisation in improving reverse supply chain efficiency. It focuses on minimising costs, reducing waste, and promoting sustainability through product recovery and recycling. The review also highlights major research trends and emerging areas in reverse logistics optimisation.

KEYWORDS: Reverse Logistics; Optimization

1. Introduction

1. Background of the study

Reverse logistics covers the backward flow of products and materials from customers through the supply chain, so that items can be returned, repaired, remanufactured, recycled or disposed of. Returns are hard to plan, since it is rarely clear when items will come back, how many there will be, or in what condition. The field is therefore treated as an Operations Research problem, where routing, inventory, facility location, cost and sustainability are decided together (Van Engeland et al., 2020; Lozano-Oviedo et al., 2024).

As studies multiply, this paper takes a bibliometric approach, using Scopus data analysed in Biblioshiny (Aria & Cuccurullo, 2017).

2. Growth and evolution of the research

A Scopus search for “reverse logistics” AND “optimization” in titles, abstracts and keywords returned 1,640 documents. After screening by period, document type, language and source type, 728 remained, and yearly output grew from 31 articles in 2016 to 139 in 2026, about 4.5 times higher. Early work centred on cost and network design (Singh et al., 2016), later work added uncertainty and remanufacturing (Ansari & Daxini, 2022), and since 2023 the focus has moved to the circular economy and AI (A. Zhang et al., 2023; Silva et al., 2025).

3. Existing literature and research gaps

The 40 references reviewed are mostly systematic, bibliometric or method-focused reviews (Almelhem et al., 2025; Chen et al., 2024; Abid & Mhada, 2021). Four gaps stand out. First, most reviews look at one sector or technology, and none combine reverse logistics, circular economy, optimization and digital tools (A. Zhang et al., 2023; Abbas et al., 2026). Second, economic objectives dominate and social aspects are

rarely modelled (Becerra et al., 2021). Third, data uncertainty is explicitly treated in only a few papers (Langenaeker et al., 2026). Fourth, machine learning is held back by scarce data and weak explainability (Silva et al., 2025).

4. Research objectives

RO1: To examine publication trends, citation patterns and country-level growth. RO2: To identify the main authors, countries, sources and keywords, and how themes have changed over time. RO3: To identify research gaps and suggest directions for future research.

2. Literature Review

1. General comments on the relevant literature

A large and growing body of literature has investigated how reverse logistics, circular economy principles (C. Zhang et al., 2023)(Lozano-Oviedo et al., 2024)(Akram, 2026)(Langenaeker et al., 2026) and supply chain management practices enable products, materials, and waste to be recovered and reused; and find out how logistics and recycling can be arranged in a way that is sustainable. Almost all of the records are review articles, so they tell us about the field as it has been previously mapped by other summaries.

Reverse logistics, circular economy and supply chain management is the largest and most advanced theme on the thematic map of the Bibliometrix, falling into the quadrant of motor themes. Recycling, systematic review and optimisation constitute a second theme, smaller but denser and more central, and local with sustainability and sustainable development, which are transitional between groups. The keyword network obtained with VOSviewer confirms the same pattern: reverse logistics, network design, uncertainty and multi-objective optimisation are very closely related to sustainability, while circular economy, machine learning and electric vehicles are clustered but separate.

2. Previous research: a historical perspective

Research into reverse logistics has a longer history than the dataset itself can. However, the review dates of the papers included in the review give us an idea. Some reviews examine articles published from 1995 to 2023 (Chen et al., 2024), while others include just papers published from 1992 onward (Ren et al., 2023), and still others examine close to 30 years of research (Pinto et al., 2023). Other reviews consider closed-loop network design studies from 1997 (Solgi et al., 2026), and papers related to green supply chain studies using AI techniques from 1999 (Abbas et al., 2026).

From 2023 onwards, there has been an increasing amount of literature framed around the circular economy (Lozano-Oviedo et al., 2024)(Langenaeker et al., 2026)(C. Zhang et al., 2023), and more sustainability and sustainable development no longer appear only with supply chain management and reverse logistics. One bibliometric review drew the landscape of the circular supply chain management literature (A. Zhang et al., 2023) by bibliometric analysis, and reports that there was confusion surrounding associated terms while no previous review has traced the development of trends.

More recent attention has focused on digital technologies, and the most recent records point to technology-oriented expansion (Abbas et al., 2026; Almelhem et al., 2025; Silva et al., 2025)(Patil et al., 2026), with machine learning, learning systems and electric vehicles appearing alongside the established circular economy and sustainability vocabulary.

3. Previous Research: methodological approaches taken

What we know about this field is largely based upon secondary evidence, since almost every record is a literature review. Several systematic reviews have been undertaken by using explicit protocols, most commonly PRISMA; for example Industry 4.0 and waste collection (Almelhem et al., 2025); machine

learning(Silva et al., 2025); battery recycling networks(Feng et al., 2026); end-of-life vehicle management(Bhattacharjya et al., 2026); humanitarian logistics(Garcia et al., 2026) and closed-loop supply chain meta-synthesis(Akram, 2026).

Publications that concentrate on research trends more frequently adopt a bibliometric or chronological approach(Abbas et al., 2026; Chen et al., 2024; Solgi et al., 2026). This approach parallels the present study's use of Bibliometrix and VOSviewer, and, using this approach, researchers have been able to identify clusters and emerging themes, although it is not designed to test hypotheses

A third group of reviews is organised around the quantitative methods that the underlying studies employ(Abid & Mhada, 2021; Ansari & Daxini, 2022; Becerra et al., 2021; Paduloh et al., 2020; Pinto et al., 2023), and much of the previous research they synthesise has focused on identifying and evaluating optimal network configurations(Solgi et al., 2026; Van Engeland et al., 2020; X. Zhang et al., 2022). Most researchers investigating reverse supply chain optimisation have utilised the modelling technique in green supply chain inventory models were mixed integer programming, metaheuristics or simulation

4. Previous Research: what has been established or proposed

Several studies have found that economic focus and aims are dominant(Becerra et al., 2021; Langenaeker et al., 2026; Lozano-Oviedo et al., 2024; Solgi et al., 2026), when modelling CE and RL problems in supply chain optimization. One review report that cost minimisation and reduction of greenhouse gases are the main aims of green inventory models(Becerra et al., 2021), and social dimensions are barely considered. Other finds that sustainable closed-loop optimisation models focus on economic and environmental aspects(Lozano-Oviedo et al., 2024), whereas social aspects are generally not incorporated. It is now well established from a variety of studies that uncertainty is common in reverse supply chains(Ghayebloo et al., 2024; Langenaeker et al., 2026; Paduloh et al., 2020; Rossit & Nesmachnow, 2022). One review finds that the most common specific uncertain elements are customer demand, total cost and product returns(Paduloh et al., 2020), while other finds that multi-criteria indices of greenness and multi-objective robust optimisation for uncertain return quality are in demand(Ghayebloo et al., 2024). Several lines of evidence from sector-specific studies suggest that implementation barriers are both structural as well as technical.(Chen et al., 2024; Yuik et al., 2023). One review reports management barrier in supply chains, such as lack of deconstruction concepts(Chen et al., 2024), lack of markets for secondary materials, complexity of secondary materials quality assessment, poor integration, and suggests a platform-based ecosystem model

Other postulates that reverse logistics, product lifecycle and zero-waste approaches create regenerative supply systems(Akram, 2026). Another review reports that research on circular supply chain design is that research on circular supply chain design is largely aimed at conceptual guidance; that dependencies between network design, inventory, reprocessing and reverse logistics are under-connected; and that centralised management is assumed by the majority of studies(Langenaeker et al., 2026). Overall, this suggests that this line of research has strong modelling foundations but less-developed understanding of integration, stakeholders and social concerns. One bibliometric review identifies five clusters in circular supply chain research and report that zero waste, industrial symbiosis, circular product design, sourcing and reuse are the least researched topics.(A. Zhang et al., 2023)

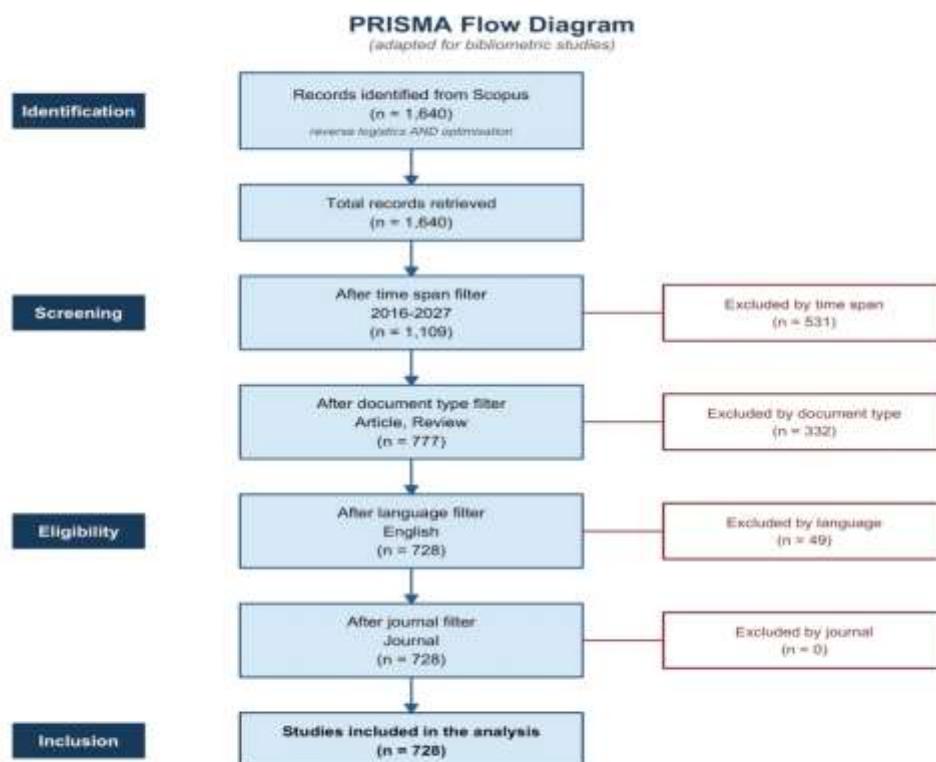
5. Stating what is currently known about the topic

A clear relationship exists between reverse logistics, circular economy and supply chain management: the 40 records, collectively, attest to the extent to which all three have grown into more closely integrated fields(Akram, 2026; Langenaeker et al., 2026; Lozano-Oviedo et al., 2024; A. Zhang et al., 2023), and

how reverse logistics has been increasingly framed as an operational instrument of circular supply chains as opposed to a mere cost recovery practice (Akram, 2026; Lozano-Oviedo et al., 2024). With regards to the thematic map, this has received support through positioning all three terms within the largest cluster on the map, within the motor-theme quadrant. In the VOSviewer network they appear tightly connected to sustainability, network design, uncertainty and optimisation, which is in line with the set of works where quantitative network design and optimisation models sit at the core analytical tradition and is one of the most important and best-developed problem areas.

There is a relatively small body of literature concerned with the social aspect of sustainability, actor engagement, remanufacturing compared to recycling, and some circular approaches including reuse (Langenaeker et al., 2026; Lozano-Oviedo et al., 2024; Yuik et al., 2023; A. Zhang et al., 2023), circular design of products and lifestyles, and several of the reviews define these areas as relatively sparsely covered. Because the bibliometric reviews review these fields independently, and most of the very recent records show starting in 2024 only, a more overall overview of where the fields reverse logistics, circular economy, optimisation, and digital technologies overlap seems to still be in a frontier. This is the vision underpinning this current work. Thus, while the body of the literature has created a strong optimisation-oriented base for reverse logistics, circular economy, and sustainable supply chain management (Becerra et al., 2021; Lozano-Oviedo et al., 2024; Van Engeland et al., 2020), its further advancement toward integrated approaches, multiple actors, social equality, and digital analytics fields seems to need further development.

3. Research Methodology



1. Research design and bibliometric approach

The increasing volume of research on reverse logistics and supply chain management has made it very di-

fficult to understand the overall development of the field by examining individual studies in isolation. In particular, the use of optimization techniques in reverse distribution has spread across areas such as network design, product recovery, recycling, waste management, transportation and sustainable supply chains. This ever-increasing breadth makes it essential to examine the existing literature systematically to identify how this field has developed, which areas have been well researched and where the potential gaps remain. Therefore, the study “Reverse Logistics Optimization: A Bibliometric Review” adopts a bibliometric research analysis to quantitatively examine the literature published in this area.

For this study, Scopus was used as primary database for collecting the literature. It was preferably chosen because it gives large, structured collection of scholarly publications along with important bibliometric information such as publication year, authors document type, source, keywords and citations. The data retrieved from Scopus was subsequently prepared for bibliometric analysis using Biblioshiny, a web-based interface of the Bibliometric package. A PRISMA-style flowchart was used in order to document the various stages through which the initial search results were screened and narrowed down to achieve the final set of studies used for analysis

2. Search strategy and initial data collection

The literature search was conducted using “reverse logistics” AND “optimization” as primary keywords. It was performed in Scopus with the search field covering Article Title, Abstract and Keywords. The Boolean operator AND was used as it was intended to retrieve those publications in which both the concepts were connected within the title, abstract or keywords, thereby keeping the search focused on the relationship between reverse logistics and optimization.

The initial search generated 1640 documents. At first, the purpose was to obtain sufficiently broad set of publications rather than immediately restricting the results by using multiple criteria. The given dataset provided a basis for observing what the publication pattern was and subsequently deciding upon the appropriate screening criteria.

3. Selection of the publication period

The first important screening criterion was the publication year. Before deciding the final period, the distribution of publications across various years was examined in Scopus. The results, when analyzed, showed a general increase in the number of publications in more recent years. For example, the filtered results showed 50 publications in 2016 compared to 183 publications in 2026, indicating the growing attention being given to this field in recent years.

Based on this publication pattern, the study focused on the period 2016-2027 so as to capture the recent development of research on reverse logistics optimization. Importantly, the Scopus results showed only 2 publications for 2027, meaning that most of the publications retained within the total selected period were from 2016-2026. By applying the year filter, the initial dataset of 1640 documents were reduced to 1109 documents resulting in the exclusion of 531 documents which were published outside the selected period. The time restriction was introduced to maintain a manageable and relevant research base while focusing on contemporary developments in reverse logistics optimization. Having a recent publication window for analysis is appropriate for this topic as optimization techniques, sustainability practices, technology applications and supply chain approaches have been developing aggressively in recent years.

4. Document-type screening

The next filter applied was by document type. There were 1109 documents remaining after applying the year filter out of which only Articles and Reviews were retained. This brought down the dataset to 777 documents which means that 332 records were excluded at this stage.

The articles and review papers were decided to be kept as they were more relevant for the objectives of the study. Research articles generally provide elaborated descriptions of research problems, methodologies, models, empirical analysis and findings. This makes them advantageous for understanding application of optimization approaches within reverse logistics. Review papers, on the other hand, provide consolidated discussions of existing research and can help identify established themes, research gaps and emerging directions within a field.

Conference papers were not taken into account as they present abbreviated research which can later be developed into complete journal publications. Book chapters were excluded for their content being less standardized and less consistent for bibliometric comparison. Conference reviews and other review-type documents were not considered because their publication formats may vary considerably across sources. Editorials were removed as they rather provide perspectives than a detailed authentic research. Notes and short communications were not considered because of their limited length which may provide insufficient methodological and empirical detail for the intended analysis. Errata and similar corrective publications were removed as they mainly amend the work which is published previously rather than constituting independent research.

5. language screening

The next screening stage involved language. The dataset was restricted to only those publications which were written in English. By applying this filter, the number of documents were reduced from 777 to 728, resulting in the exclusion of 49 publications.

English was chosen as the language criterion because it was the language in which most of the researchers across the globe could read, interpret and analyze the selected literature. Applying a common language also helped maintain consistency while examining titles, abstracts, keywords and other bibliographic information during the subsequent analysis. This criterion was therefore a practical and methodological decision rather than having an assumption that the papers published in other languages are less relevant or less valuable.

6. Source-type screening

The last filter applied concerned the source type of the publications. The dataset was limited to documents classified as journal sources. Interestingly, using this filter did not result in removal of any additional records. All the 728 documents remaining after applying the language filter were already classified as journal publications in Scopus.

Therefore, the number remained unchanged at 728 documents. Even though this filter did not reduce the dataset, it was kept in the methodology because it confirmed that the nature of the final publication set and ensured that there is consistency between the intended eligibility criteria and the records actually included in the study.

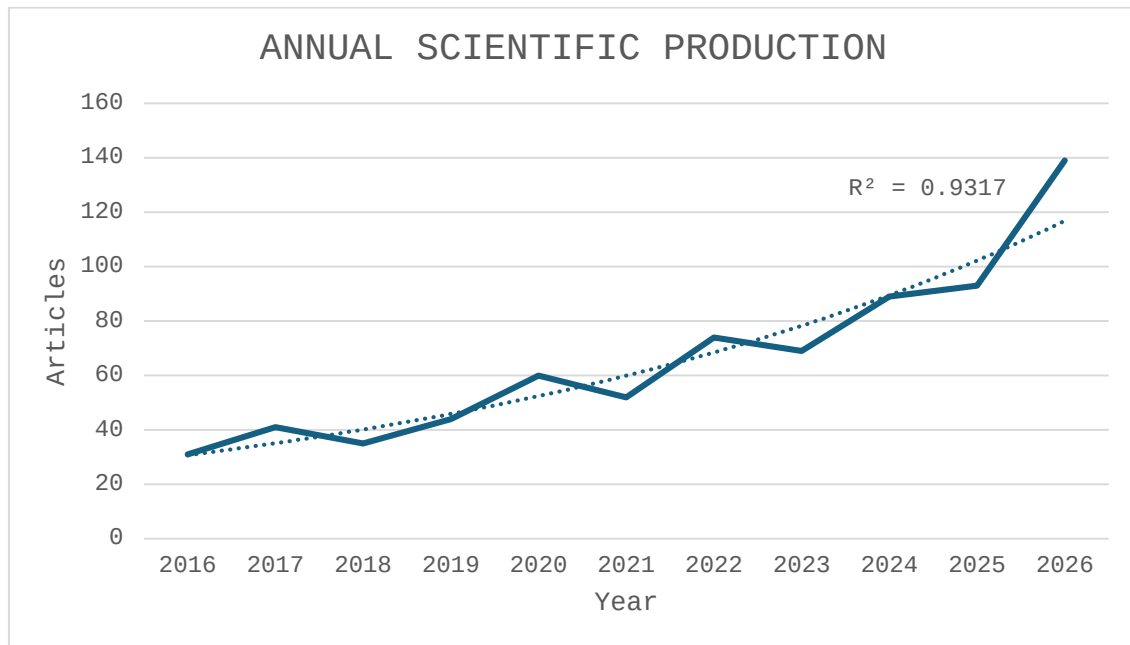
7. Final dataset and prisma screening process

The entire screening process filtered the data from the 1640 Scopus records to 728 final studies. The order of filtering was: publication period, document type, language and source type. It was then exported in both RIS and BibTeX format and used for further analysis in Biblioshiny. The PRISMA flow diagram visually represented the complete filtering process and ensured that there was transparency in how the final dataset has been obtained. The bibliographic information in the dataset formed the basis for examining the publication and citation structure of research on reverse logistics optimization, along with other relevant bibliometric patterns. Thus, this research methodology ensured that the analysis was based on a well-defined set of records instead of a random selection of papers.

Overall, the screening process was designed to balance both breadth and relevance. The initial search was intentionally broad enough so that the entire available literature on reverse logistics and optimization can be captured, while the additional criteria narrowed the dataset to recent, English-language journal articles and review papers. This provided a structured foundation for the bibliometric analysis presented in the subsequent sections of the research paper.

4. Data Analysis

1. Annual Scientific Production



The first chart shows how many articles about reverse logistics were published each year from 2016 to 2026. The number went up a lot during these years. There were 31 articles in 2016. By 2026, the number had reached 139. This is about 4.5 times more than in 2016.

The number did not increase every year. There were small drops in 2018 and 2023. In 2018, there were 35 articles, and in 2023, there were 69. Even with these drops, the overall number of articles kept going up. After 2021, the increase became more noticeable.

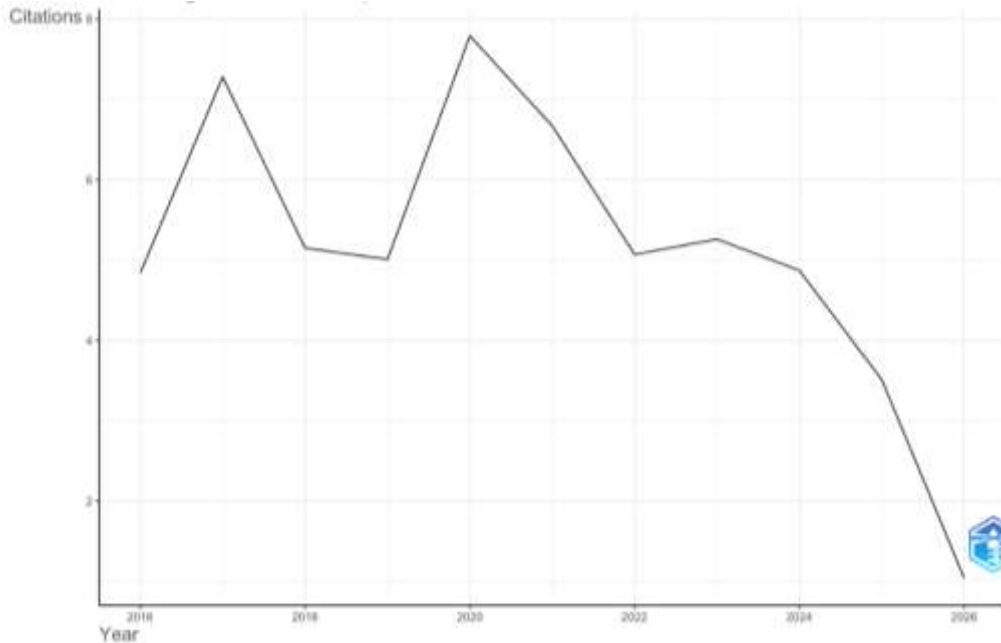
The chart also has an exponential trendline. Its R^2 value is 0.9189. R^2 shows how closely the trendline matches the actual numbers. It can range from 0 to 1. Since 0.9189 is close to 1, the trendline matches the data quite well.

This shows that the number of articles increased faster in the later years. However, it does not mean that the number will continue to increase at exactly the same speed every year.

There are 727 documents in the dataset. The 2026 number should be viewed carefully because the year may not be over yet. More articles may also be added when the research database updates its records.

Overall, the chart shows that reverse logistics is becoming a more common subject for research. The growing number of articles also shows why a review of the existing research is useful.

2. Average Citations Per Year

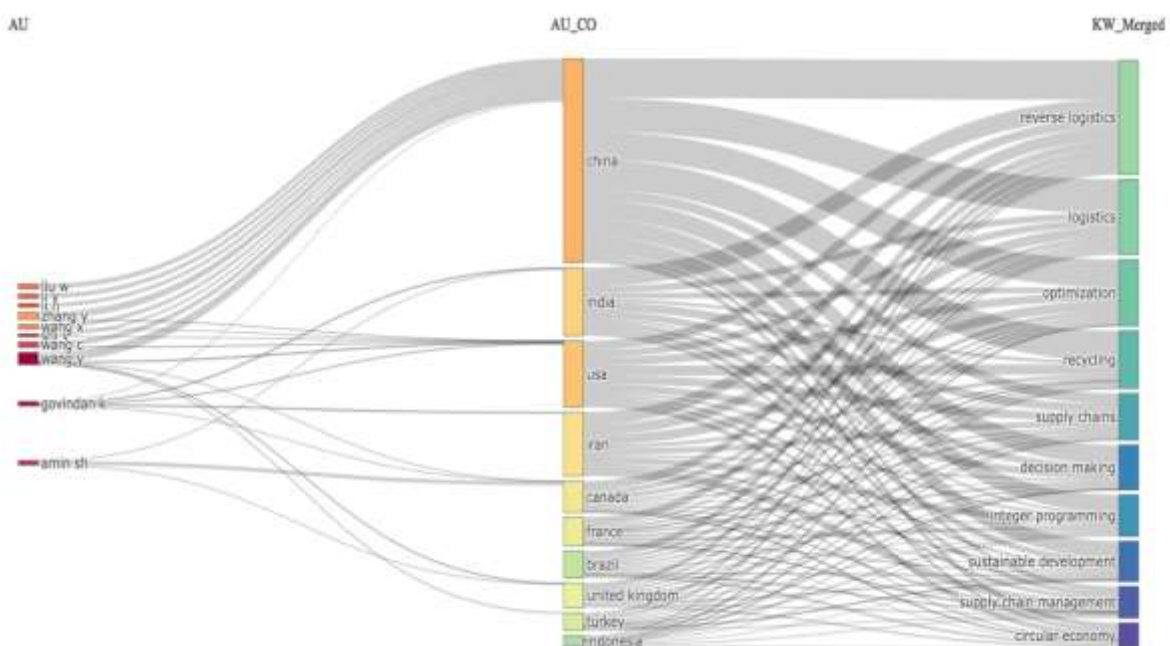


they have had more time to receive citations. Articles from 2025 and 2026 are still new, so other researchers may not have had enough time to read and cite them.

The high numbers in 2017 and 2020 may also be caused by a few articles that received many citations. For example, if one article received a very high number of citations, it could increase the average for that year.

Because of this, the chart should be read carefully. It mainly shows that older articles have had more time to receive citations.

3. Three Field Plot



The Three-Field Plot is a science-mapping visualization that connects three fields of the dataset: authors (AU) on the left, author countries (AU_CO) in the middle, and merged keywords (KW_Merged) on the right. This visualization was generated using Biblioshiny, a graphical interface for bibliometric and science-mapping analysis. (Aria & Cuccurullo, 2017a)

The plot combines all three fields in a single view, while each field was limited to its top 10 items to keep the diagram readable. Science-mapping approaches such as these are used to identify relationships and structures within a research field. (Chen, 2017)

The main authors include Liu W, Li Y, Zhang Y, Wang X, Wang C, Wang Y, Govindan K and Amin Sh. Many of these authors are connected to China. China is the largest country here.

The other countries shown are India, the USA, Iran, Canada, France, Brazil, the United Kingdom, Turkey and Indonesia.

Govindan K and Amin Sh are connected to more than one country. This may mean that they worked with researchers from different countries. However, the figure does not show all the details about these research links.

The most common keyword is “reverse logistics”. Other common keywords include logistics, optimization, recycling, supply chains, decision making, integer programming, sustainable development, supply chain management and circular economy.

The connection between China, reverse logistics and optimization shows that many studies from China look at ways to solve reverse logistics problems. These studies often use maths and computer methods to find the best answer. Yu and Solvang (2016) also discuss this type of research. (Yu & Solvang, 2016)

Other common keywords are recycling, sustainable development and circular economy. This shows that reducing waste and helping the environment are important parts of reverse logistics research. Li et al. (2016) also discussed these topics. (Li et al., 2016)

Overall, the figure shows the main authors, countries and topics in the research. It shows that reverse logistics is linked to supply chains, recycling and ways of finding better solutions.

4. Most Relevant Sources

Sources	Articles
JOURNAL OF CLEANER PRODUCTION	63
COMPUTERS AND INDUSTRIAL ENGINEERING	35
SUSTAINABILITY (SWITZERLAND)	29
INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	23
ANNALS OF OPERATIONS RESEARCH	14
TRANSPORTATION RESEARCH PART E: LOGISTICS AND TRANSPORTATION REVIEW	13
EXPERT SYSTEMS WITH APPLICATIONS	11
JOURNAL OF ENVIRONMENTAL MANAGEMENT	10
PROCESS INTEGRATION AND OPTIMIZATION FOR SUSTAINABILITY	9
IEEE ACCESS	8
INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS	8

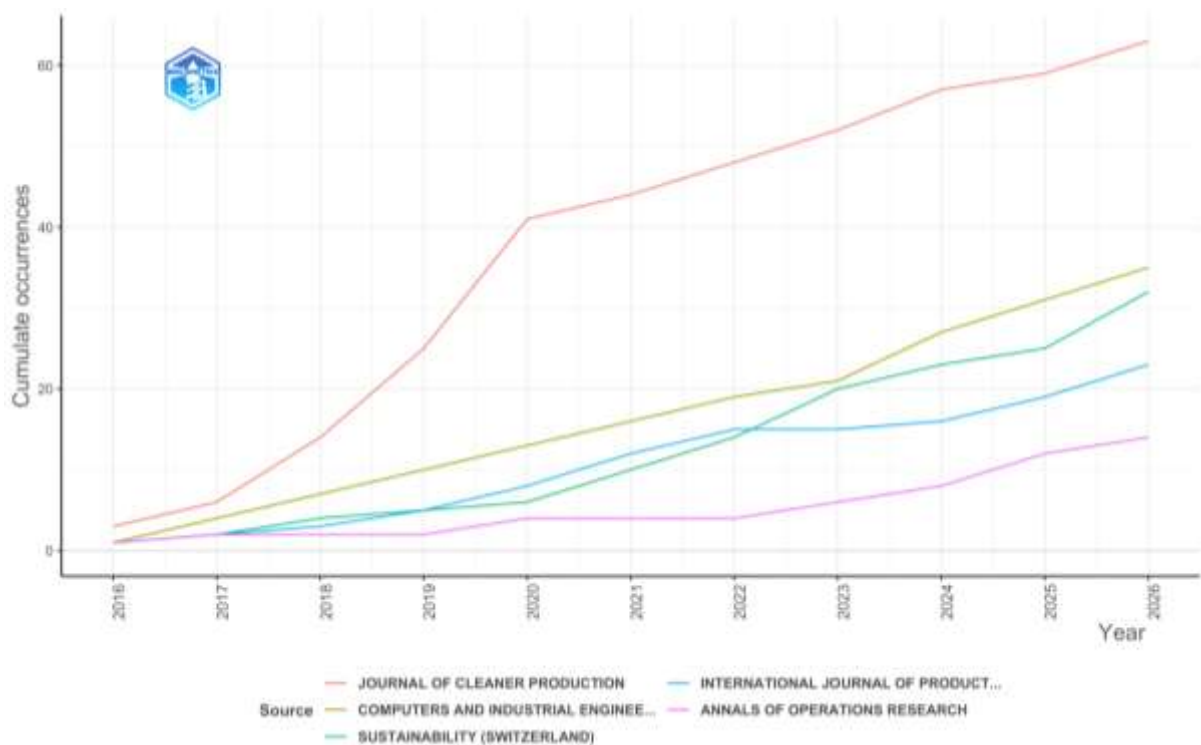
The table shows that most reverse logistics articles are published in a small number of journals. The *Journal of Cleaner Production* has the highest number, with 63 articles. *Computers and Industrial Engineering* is next, with 35 articles.

The top three journals together have more than one-third of the articles listed in the top 10 journals. This means that a small number of journals publish a large amount of the research in this area.

Many of these journals publish articles about the environment, factories, business work and supply chains. These topics are related to reverse logistics. Reverse logistics can include recycling, reducing waste, planning transport, lowering costs and handling products that are sent back.

The *Journal of Cleaner Production* is the main journal for reverse logistics research. Journals about industrial engineering and operations research also publish many articles on this topic. The table shows that reverse logistics is studied in different ways. Some researchers study waste and problems related to the environment. Other researchers look for cheaper and better ways to manage returned products, waste and transport.

5. Sources' Production over Time



The fifth chart shows the total number of reverse logistics articles published by the five main journals from 2016 to 2026.

These numbers are added together each year. This means that the total can only go up or stay the same. It cannot go down. If a line stays flat, it means that the journal published very few or no new articles during that time.

The *Journal of Cleaner Production* stayed in first place during the whole period. It had 3 articles in 2016 and reached 63 articles by 2026. Its number increased quickly between 2019 and 2020. During this time, the total went from 25 to 41 articles.

Computers and Industrial Engineering followed a similar path, but its total was lower. It increased from 1 article in 2016 to 35 articles in 2026.

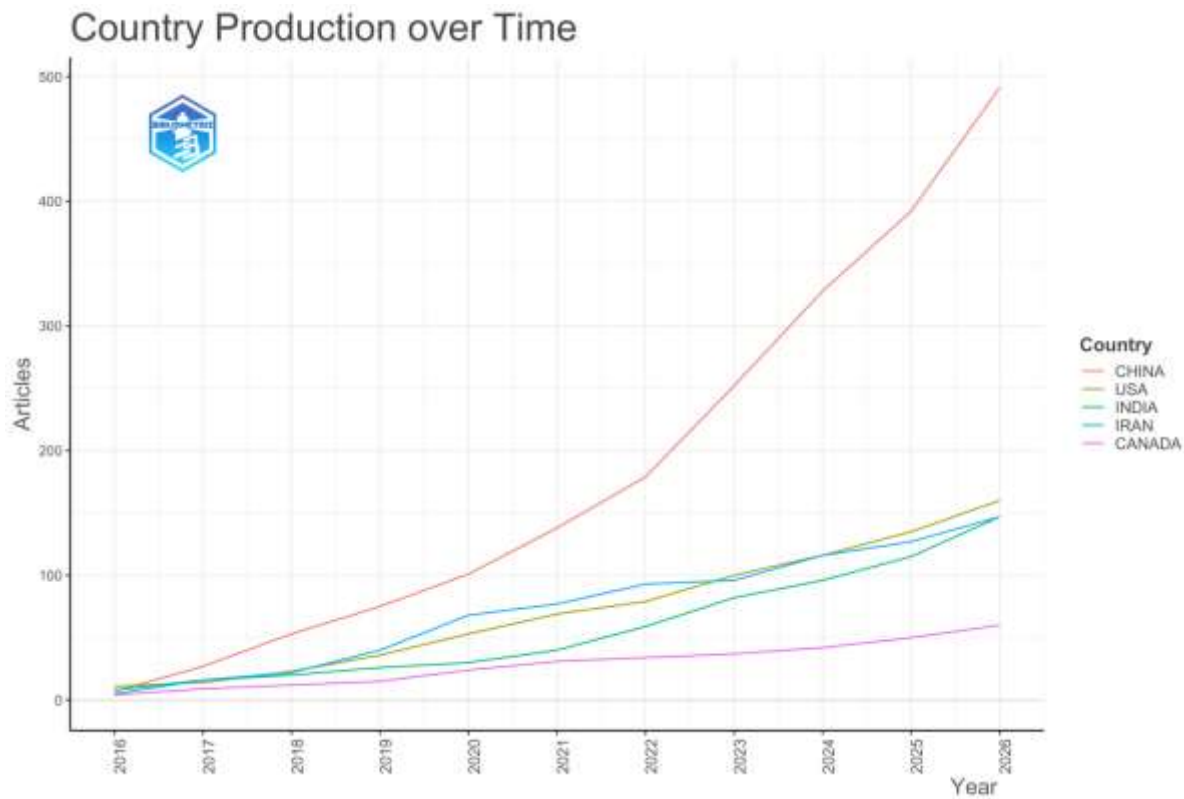
Sustainability (Switzerland) grew more slowly in the first few years. However, its number of articles increased after 2022. By 2026, it had 32 articles. This was close to the 35 articles published by *Computers and Industrial Engineering*.

The *International Journal of Production Research* had 23 articles by 2026. *Annals of Operations Research* had 14 articles. These two journals grew more slowly than the first three journals.

The chart shows that the *Journal of Cleaner Production* was the main journal for reverse logistics articles during this period. However, other journals also started publishing more articles, especially *Sustainability (Switzerland)*. This means that reverse logistics research is now being published in more journals.

6. Countries Production over Time

FOR CHINA, USA, INDIA, IRAN, CANADA



The chart shows the total number of reverse logistics articles published by five countries from 2016 to 2026. The countries are China, the USA, India, Iran and Canada.

China had the highest number of articles by far. In 2016, China had 7 articles. This was close to the numbers for the other countries. After about 2021, the number of articles from China rose very quickly. It went to 491 articles by 2026. This is more than thrice the number of articles from the next country.

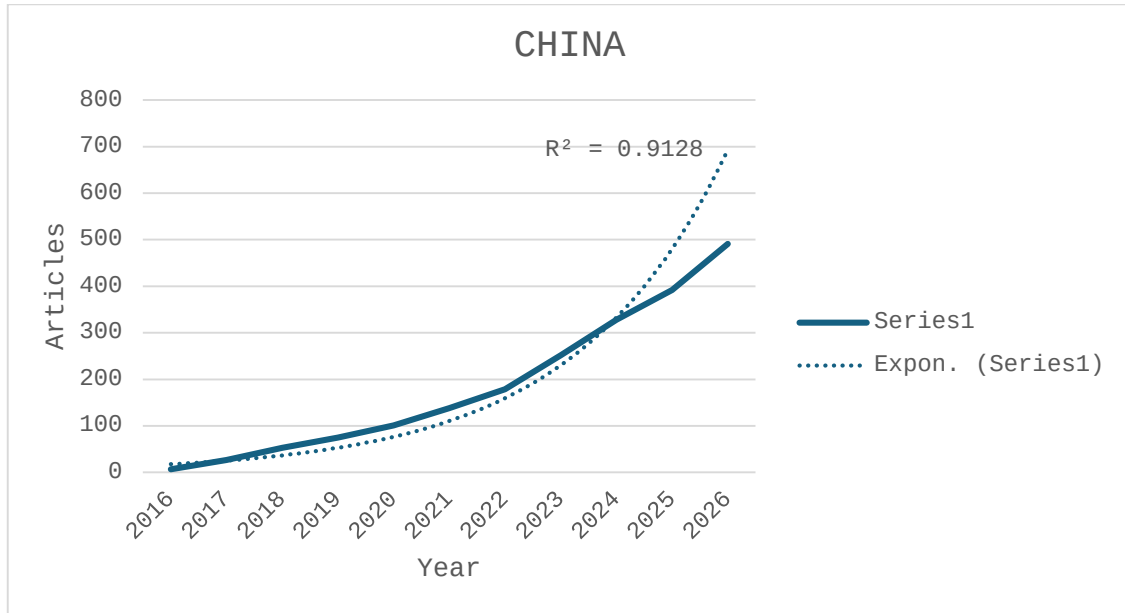
Canada had the lowest number of articles. It reached 60 articles by 2026. Its growth was slower than the growth of the other four countries.

The chart also has a curved trendline for each country. This type of line shows that the number of articles grew faster in the later years. All five countries had data for the years shown, so a trendline could be added for each one.

The R^2 values were between 0.8504 for Iran and 0.9857 for India. R^2 shows how closely the curved line matches the real numbers. These values show that the lines match the data quite well.

The results show that reverse logistics research increased in all five countries. China had the fastest growth by far. The numbers for 2026 may still change because the year may not be finished.

Individual Country Charts

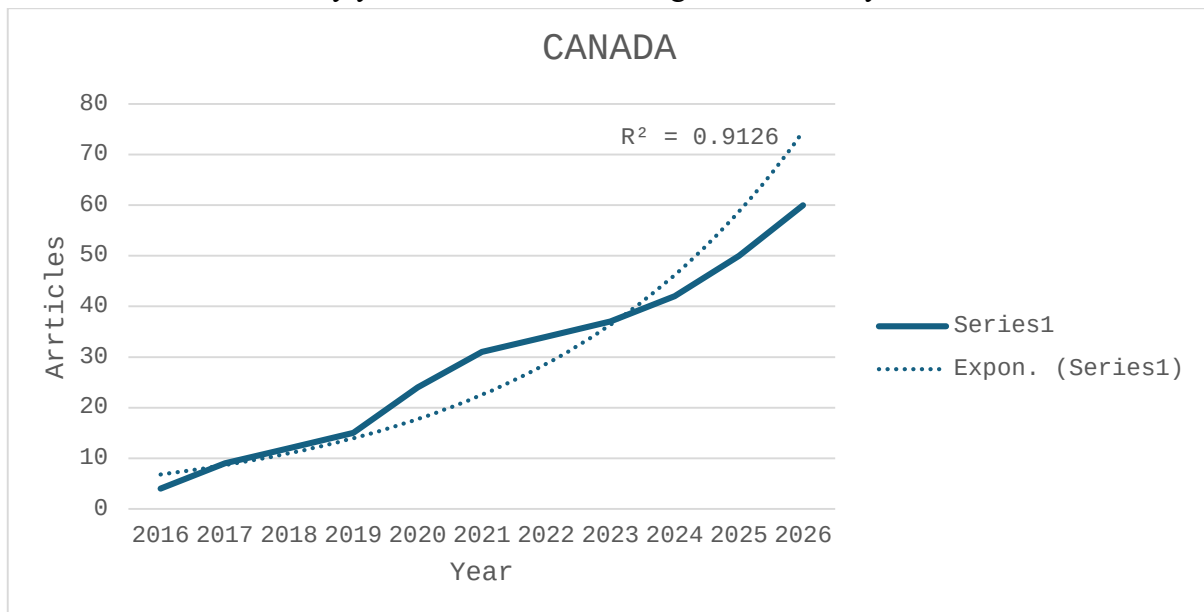


China had the biggest increase in articles among all the countries in the dataset. It had 7 articles in 2016 and 491 articles in 2026.

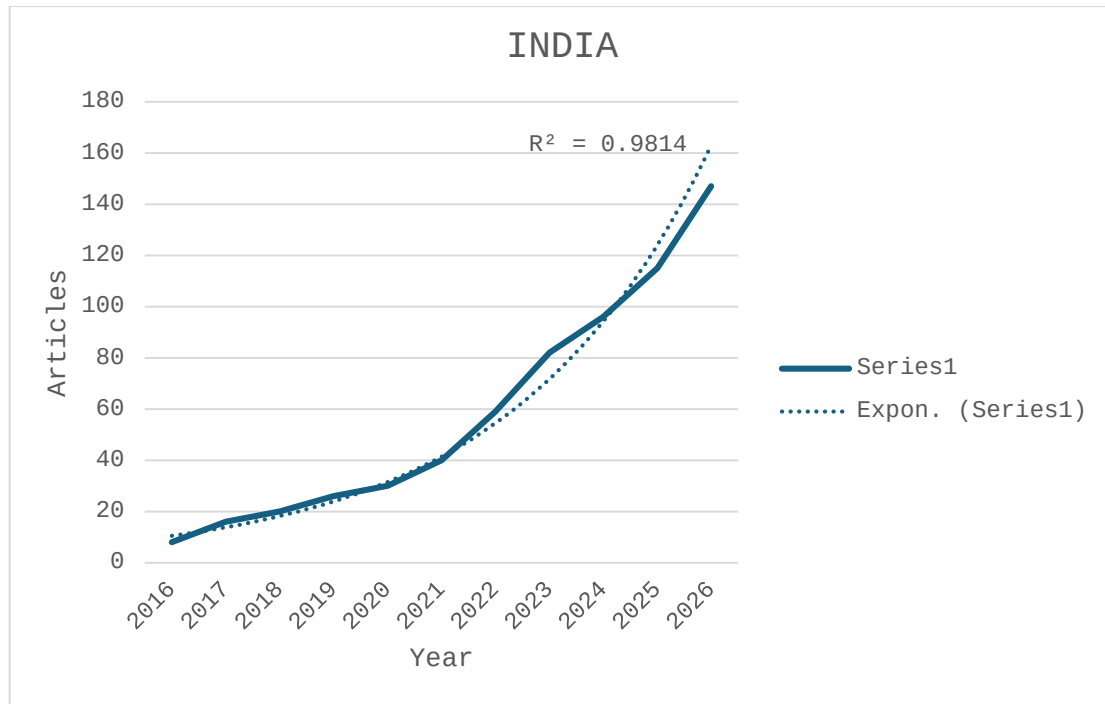
The increase was slow at first. By about 2020, China had 101 articles. After that, the number went up much faster. It went to 491 articles in 2026.

The curved trendline for China has an R^2 value of 0.9569. This means that the line follows the real numbers quite closely.

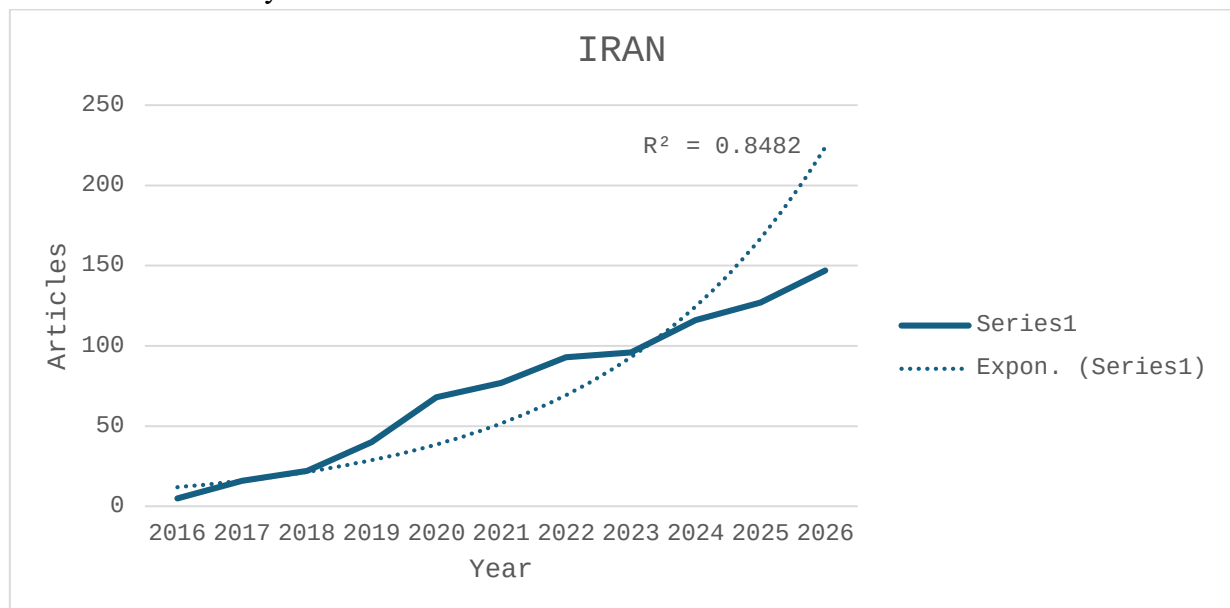
The results show that research on reverse logistics grew very quickly in China, especially after 2020. The increase was not the same every year. It became much larger in the later years.



Canada had 4 articles in 2016 and 60 articles in 2026. It had the lowest total among the five countries. The number of articles increased slowly at first. After 2020, the increase became more noticeable. The number went from 24 articles to 60 articles over the next five years. The curved trendline for Canada has an R^2 value of 0.9346, which is considered **very good**. Although Canada had fewer articles than the other countries, its research in reverse logistics still increased during that period.



India had 8 articles in 2016 and 147 articles in 2026. The number of articles increased slowly until about 2021, when India had 40 articles. After that, the number increased faster. It went from 59 to 147 articles in 2026. India had an R^2 value of 0.9857. This was the **highest** R^2 value among the five countries. It means that the curved trendline was very close to the real numbers for India.



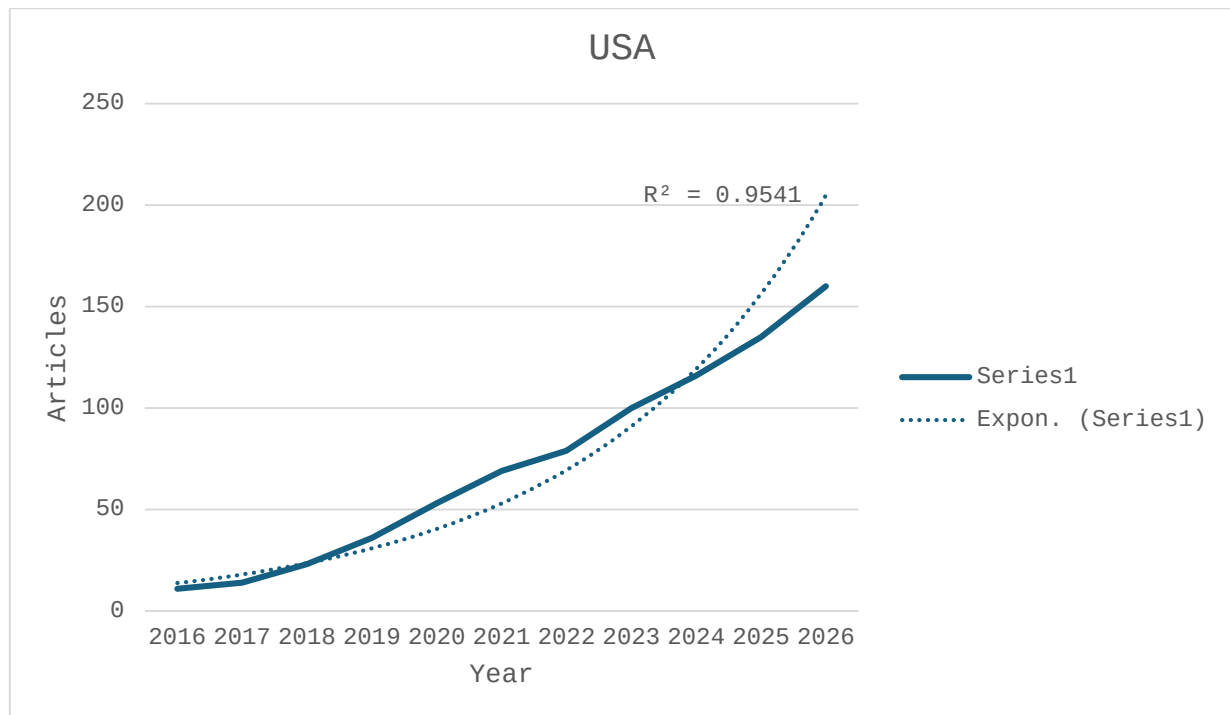
The chart shows that research on reverse logistics grew strongly in India, mainly after 2021.

Iran had 5 articles in 2016 and 147 articles in 2026. This was the same final total as India.

Iran grew faster than India during the earlier years. By 2020, Iran had 68 articles. However, its growth slowed during the last two years. India then caught up and reached the same total by 2026.

Iran had an R^2 value of 0.8504. This was the **lowest** value among the five countries, but it still shows that the curved line follows the data fairly well.

The lower value may be because Iran's growth was not as even as the growth of the other countries. The number of articles changed more from year to year.



The USA had 11 articles in 2016 and 160 articles in 2026. It had the highest final total after China.

The number of articles increased in a steady way. It went from 53 to 160 in 2026. Unlike China, the USA did not have one very large jump in the later years.

The curved trendline for the USA has an R^2 value of 0.9482, which is also considered **good**. It means line follows data closely.

The results show that research on reverse logistics in the USA grew steadily during the whole period.

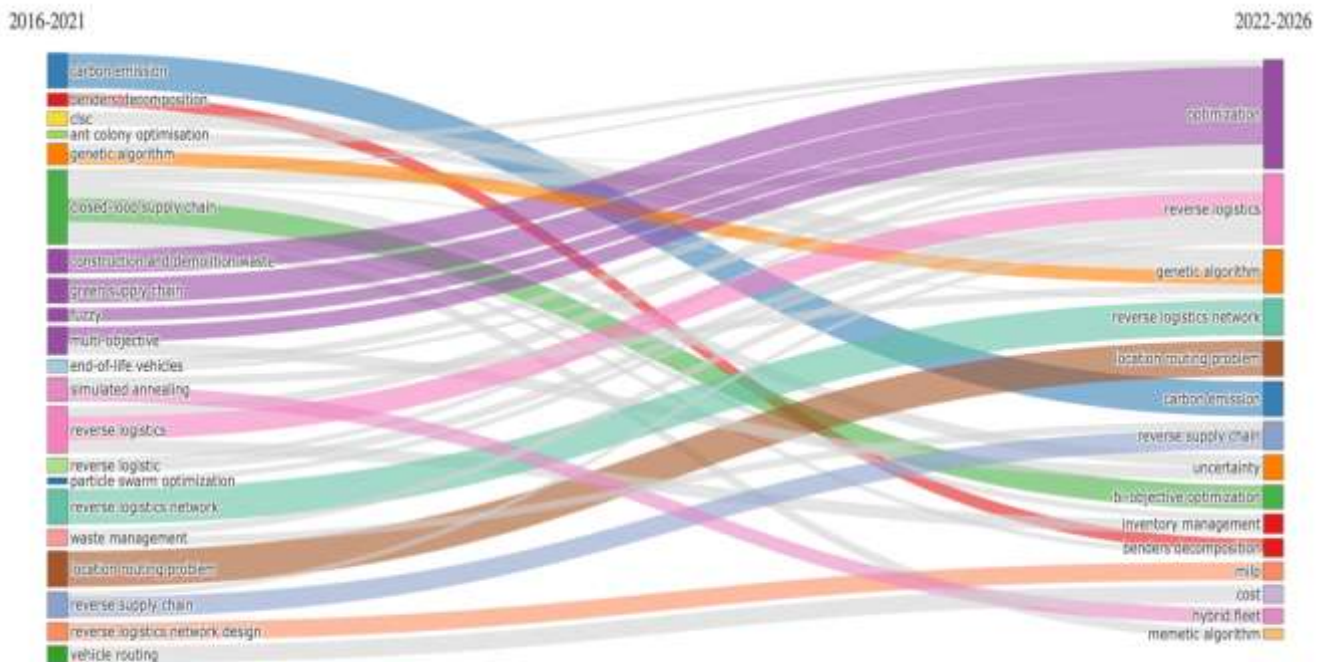
Overall result

The R^2 values for the six charts were between 0.8504 and 0.9857. These values show that the curved trendlines match the data quite well.

This means that the number of reverse logistics articles increased in the countries studied. In most cases, the increase became faster in the later years. China had the biggest and fastest increase, while Canada had the smallest total.

The trendlines help show the general direction of the data, but they do not prove that the number of articles will continue to grow at the same speed. Also, the 2026 figures may change if more articles are added to the database.

7. Thematic evolution



The alluvial diagram compares the research topics from two periods: 2016–2021 and 2022–2026. The first side shows the older period. The second side shows the newer period.

Here we used the Walktrap algorithm inside Biblioshiny to group similar topics. Biblioshiny is a tool used for bibliometric and science-mapping analysis (Aria & Cuccurullo, 2017b). The number of words was limited to 200 to avoid cluttering. The bands between the two sides show how the topics were linked between the two periods. A wider band means that the link was stronger.

Some topics changed position or joined with other topics. For example, construction and demolition waste, green supply chain, fuzzy methods and multi-objective methods from the first period became more closely linked with optimization in the second period.

Optimization means using maths to find the best answer to a problem. This may show that researchers started to use more models to solve reverse logistics problems. Instead of looking at many small topics one by one, they started bringing some of them together under optimization. Abid and Mhada (2021) also discussed the use of optimization in this area. (Abid & Mhada, 2021)

Some new topics appeared in the 2022–2026 period. These include uncertainty, inventory management, cost, hybrid fleet, bi-objective optimization, memetic algorithm and mixed-integer linear programming, or MILP. (Yu & Solvang, 2017)

These topics show that newer studies are looking more at costs, possible problems and ways to get better answers. Closed-loop supply chain and end-of-life vehicles were more common in the first period but became less important in the second period.

Overall, the main subject did not change. Reverse logistics stayed at the centre of the research. The main change was in the way researchers studied it. Newer studies look more at cost, uncertainty and maths-based ways to solve problems.

8. Before covid vs after covid

Two topic maps were made using the InfoMap algorithm. This method was used because it made the grou-

ps easier to see than the other method that was tested.

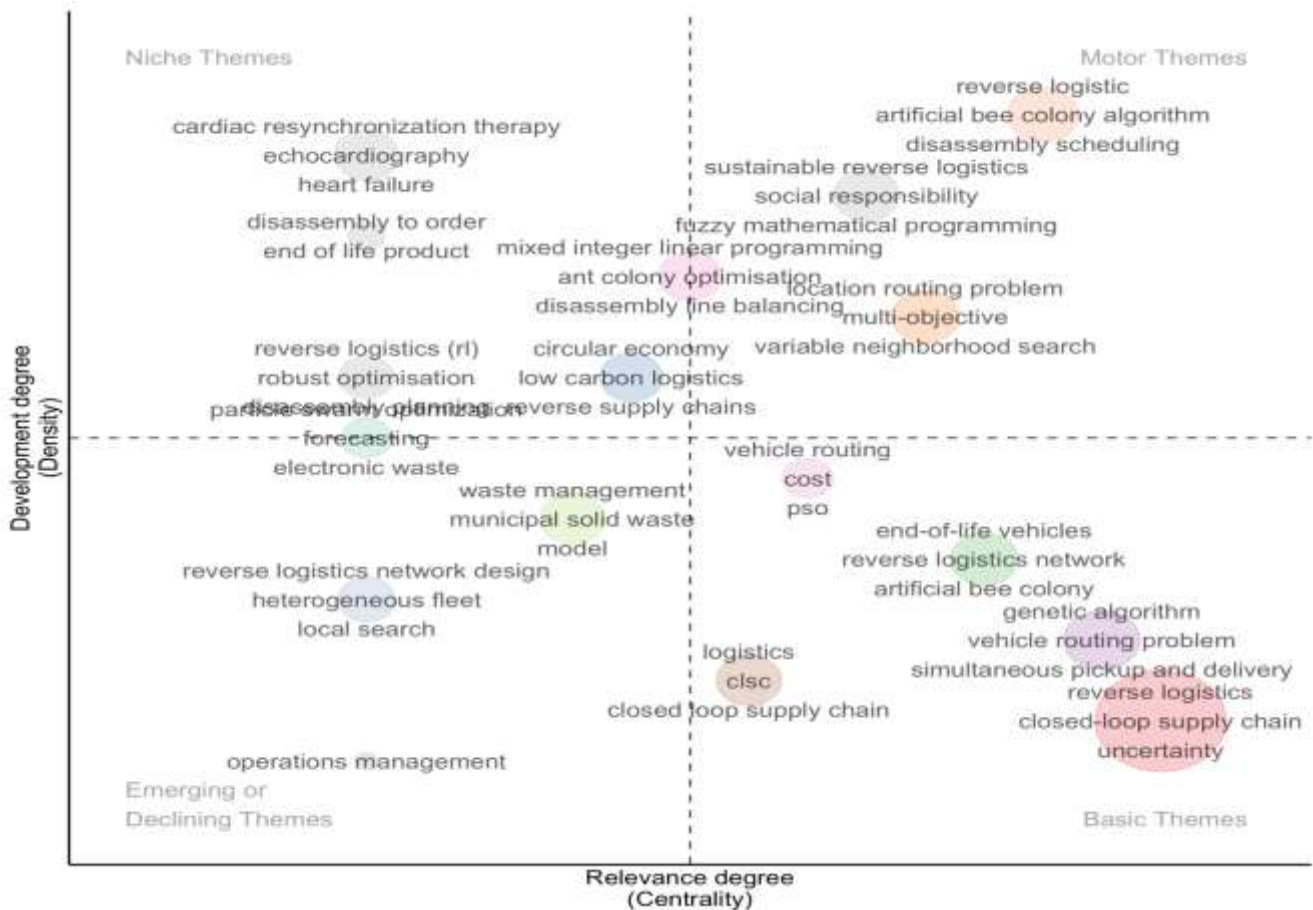
The number of words was limited to 200 on each map. This was done so that the maps would not become too crowded.

Each map has four areas:

- Motor themes: topics that are important and well-studied. These are in the top right.
- Niche themes: topics that are well studied but are not a main part of the field. These are in the top left.
- Basic themes: topics that are important but still need more study. These are in the bottom right.
- Emerging or declining themes: topics that are either new or losing attention. These are in the bottom left.

The size of each bubble shows how often the topic appears in the research. A bigger bubble means that the topic appears more often.

2016-2021



2016–2021 period: The map for 2016–2021 divides the topics into four areas.

The biggest bubble is in the basic themes area. It includes reverse logistics, closed-loop supply chain and uncertainty. These topics were closely linked to the main subject during this period.

Other basic topics include genetic algorithm, vehicle routing problem, simultaneous pickup and delivery, end-of-life vehicles and reverse logistics network. This shows that researchers were studying the movement of returned products, transport and the way reverse supply chains are set up.

The motor themes area includes artificial bee colony algorithm, disassembly scheduling, sustainable reverse logistics, social responsibility, fuzzy mathematical programming, location routing problem and multi-objective methods.

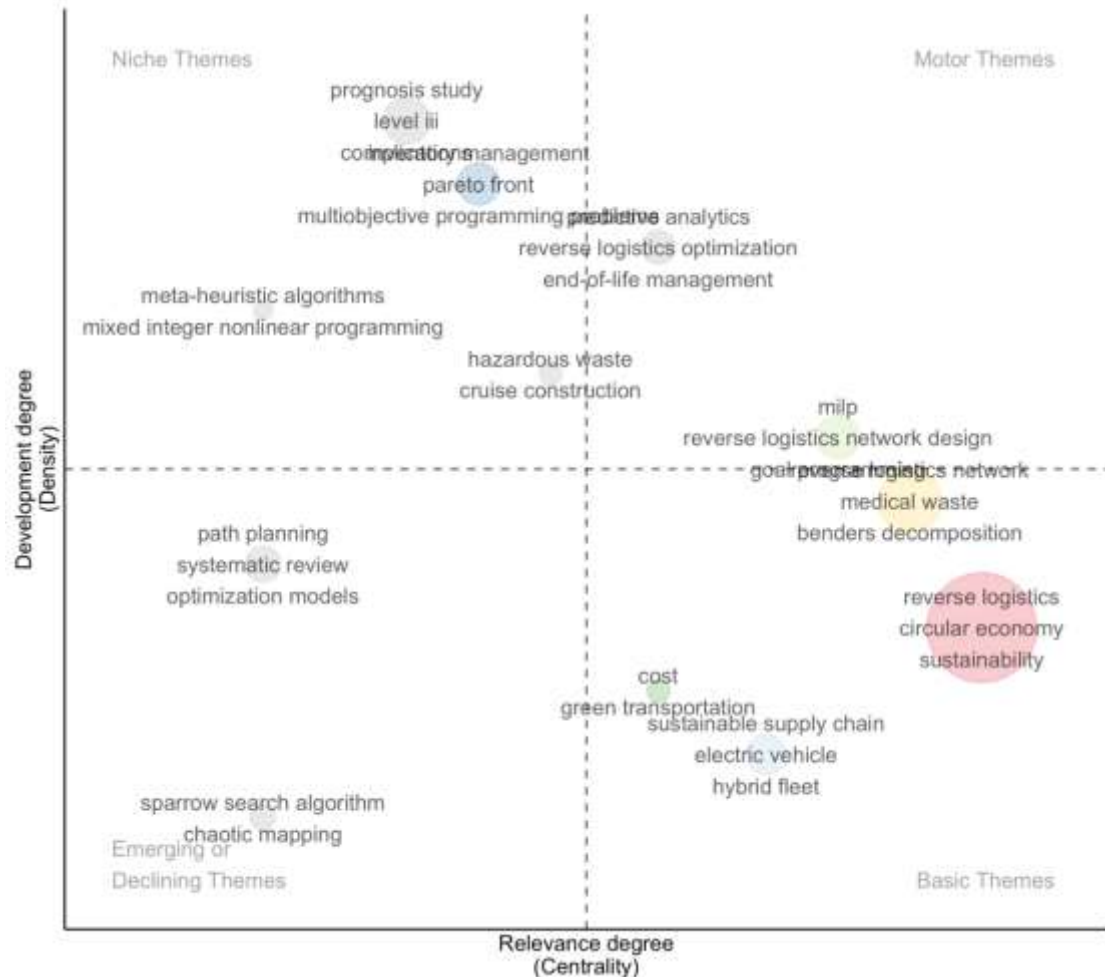
These topics were important and had already been studied by many researchers. Most of them are about computer methods, maths and reducing harm to the environment.

Circular economy and low carbon logistics (Cao et al., 2021) were near the middle of the map. This means that they were becoming more important but were not yet among the main topics.

The emerging or declining area includes waste management, municipal solid waste and operations management. These topics had weaker links with the main research topics. They may have been new topics or topics that were receiving less attention.

Overall, the map shows that research from 2016 to 2021 mainly looked at supply chains, transport, returned products, computer methods and the environment.

2022-2026



2022–2026 period: The map for 2022–2026 shows some changes from the earlier map.

The biggest basic-theme bubble includes reverse logistics, circular economy and sustainability.

This shows that circular economy became more closely linked with reverse logistics. It moved from being a growing topic to being part of the main group of topics.

Other basic topics include medical waste, goal programming, Benders decomposition, MILP, sustainable supply chain, electric vehicles, hybrid fleet and green transportation.

These topics show that newer research is looking at more than returned products. It also looks at medical waste, cleaner transport and more detailed maths models.

Medical waste became an important topic in this period. This may be linked to the extra attention given to medical and dangerous waste during the COVID-19 period. But, more proof would be needed to say that COVID-19 directly caused this change.

The niche themes include Pareto front, multi-objective programming, metaheuristic algorithms and mixed-integer nonlinear programming. These topics have been studied in some detail, but they are not as close to the main part of the field as reverse logistics, circular economy and sustainability.

Reverse logistics optimization, predictive analytics and end-of-life management are near the middle of the map. This may mean that they are starting to become more important.

The emerging or declining area includes sparrow search algorithm, chaotic mapping and path planning. These are newer methods. They appear in recent studies, but they are not yet main topics in the field.

Overall, the newer map shows more interest in circular economy, care for the environment, medical waste, electric vehicles and hybrid fleets. The main topic is still reverse logistics, but researchers are now looking at more types of problems and using more maths-based methods.

Comparison of the two maps

Point	Earlier period: 2016–2021	Later period: 2022–2026
Main basic topics	Mainly included vehicle routing, closed-loop supply chain, end-of-life vehicles, reverse logistics network and uncertainty.	Mainly included reverse logistics, circular economy, sustainability, medical waste, cost and green transportation.
Main motor topics	Included artificial bee colony algorithm, disassembly scheduling, sustainable reverse logistics, social responsibility, fuzzy mathematical programming, ant colony optimisation and location routing problem.	Included predictive analytics, reverse logistics optimization, end-of-life management, MILP, goal programming and logistics network.
Transport focus	The research focused more on vehicle routing, location routing, pickup and delivery and different types of vehicle fleets.	The research moved more towards electric vehicles, hybrid fleets and green transportation.
Waste focus	Waste management, electronic waste and municipal solid waste appeared in the emerging or declining area. This means they were not yet main topics.	Medical waste became part of the basic themes. Hazardous waste also appeared as a niche topic, so waste linked to health and safety received more attention.

Research methods	Researchers mainly used genetic algorithms, artificial bee colony methods, ant colony methods, fuzzy maths and local search.	Researchers used MILP (called as mixed-integer nonlinear programming), Benders decomposition, goal programming, predictive analytics and newer search methods such as the sparrow search algorithm.
Environment and supply chains	Circular economy and low-carbon logistics were still growing topics. Closed-loop supply chain was a more common main topic.	Circular economy and sustainability became main topics. The focus also moved towards sustainable supply chains and greener transport.

5. Conclusion

1. Overview

This study analysed 728 English-language journal articles and reviews from Scopus (2016–2026) using Biblioshiny. Research activity on reverse logistics optimization has grown strongly, and its focus has moved from costs and networks towards uncertainty, sustainability and the circular economy.

2. Research Objective 1

Output rose from 31 articles in 2016 to 139 in 2026. An exponential trendline fits the data well ($R^2 = 0.9189$), although growth dipped slightly in 2018 and 2023, and the 2026 figure may be incomplete. Falling average citations mostly reflect the shorter time recent papers have had to be cited. China led in cumulative output (491 papers), followed by the USA (160), India and Iran (147) and Canada (60), though these counts show volume, not quality.

3. Research Objective 2

Leading authors include Liu W, Li Y, Zhang Y and Govindan K. The Journal of Cleaner Production was the leading source (63 articles), followed by Computers and Industrial Engineering (35) and the International Journal of Production Research (23). Between 2016–2021 and 2022–2026, themes such as closed-loop supply chains, end-of-life vehicles and fuzzy methods gave way to uncertainty, inventory, MILP, hybrid fleets, circular economy and medical waste.

4. Research Objective 3

Future work should move beyond cost to multi-objective models that include emissions, recovery value, service level and social aspects (Becerra et al., 2021; Lozano-Oviedo et al., 2024). Robust stochastic models should handle uncertain returns, machine learning could predict return volumes to guide collection decisions (Silva et al., 2025), and models need validation with company data (Almelhem et al., 2025).

5. Implications and limitations

The study maps the field's shift from routing and closed-loop networks to circular economy and sustainability. For managers, return planning must allow for uncertain demand, costs and returns (Paduloh et al., 2020); for policy, incentives are linked to better collection (Esmaeilian et al., 2026). Limitations include reliance on Scopus, exclusion of conference papers and book chapters, and incomplete 2026 data.

6. Future Research Agenda

1. How the thematic map was used

The map for 2022-2026 is a highly mathematical field as MILP, Benders decomposition, goal programming, Pareto-front optimization and metaheuristic techniques fuel both the core and the niche areas. The reverse logistics, circular economy and sustainability are core concepts needing further investigation. Predictive analytics is placed near the centre as a growing concept whereas sparrow search algorithm and chaotic mapping are from the emerging areas. Keyword frequency analysis was made based on the titles, abstracts and keywords of 727 bibliographic entries.

2. Identified research gaps

- Digital Technologies:** Blockchain features in 12 papers (1.7%). IoT figures in 13 digital twins occur in 12. Industry 4.0 features in 13 mainly in 2025-2026. Tizmaghz et al. (2026) Yang et al. (2026). Abbasi et al. (2025). Future work could assess the impact that live sensor data and traceability data have on decision making and the value of using these technologies.
- Predictive Methods:** 21% of papers feature metaheuristics while around 7% feature machine learning. Geraeli and Roghanian (2026) have real-time data and machine learning in their paper regarding fruit-waste network. Newer models will also need to be assessed since the performance of these models depends heavily on how well the parameters have been set (Shadkam, 2022).
- Social Considerations:** Consumer behaviour comes out in around 8 cases, while most of the models assume the return to be constant. Review literature indicates that social goals are seldom modelled (Becerra et al., 2021; Lozano-Oviedo et al., 2024) and Erlina et al. (2026), and Meng and Okwara (2024) are exceptional.
- Industrial Sectors:** Medical and hazardous wastes and electric vehicles are covered sufficiently. Textiles, small businesses and food waste are not. Sumo et al. (2023) call for textiles research and end-of-life batteries represent a developing case (Mejía-Moncayo et al. 2026). In end-of-life vehicle networks, remanufacturing has been less researched than recycling (Yuik et al., 2023).
- Resilience:** Parameter uncertainty is widely researched (Yu & Solvang 2017). Data uncertainty is dealt with only by a handful of publications (Langenaeker et al. 2026). In addition, there are 24 records on epidemics, although medical waste has become fundamental since 2021. The coronavirus connection needs to be empirically proved rather than simply assumed.

3. Proposed Research Agenda

Table 1. Converts these gaps into research questions and a suitable approach.

Gap area (map position)	Evidence	Future research questions	Approach
1. Digital technologies (Absent from map)	Digital technologies such as <u>Blockchain</u> , <u>IoT</u> digital twin and Industry 4.0 appear in 12–13 of 727 records. None appear on the 2022–2026 map.	RQ1: How can live <u>IoT</u> or <u>Blockchain</u> data feed reverse logistics network models? RQ2: Do technology costs outweigh the savings from tracking of returns?	Digital-twin simulation; company case studies. The authors have seen that Digital technologies are missing from recent studies.

2. Predictive methods (Emerging – near centre)	Predictive methods such as analytics sit near the centre of the map. Machine learning appears in 7% of records. <u>Metaheuristics</u> appear in 21% of records.	RQ3: Can machine learning forecast the volume and condition of returns enough to improve network design? RQ4: Do predict-optimize models outperform static optimisation?	MI + MILP; rolling-horizon optimisation. The authors have seen that Predictive methods are gaining attention but are still not fully integrated.
3. Consumers and social aspects (Absent / Declining)	Consumers and social aspects such as consumer behaviour appear in 8 records. Social responsibility was a motor theme in 2016–2021. Is missing from 2022–2026.	RQ5: How do incentives and convenience change return rates? RQ6: How can jobs and informal recycling be modelled as objectives?	Surveys with optimisation; agent-based simulation. The authors have seen that Consumers and social aspects are underrepresented in the literature.
4. Sector coverage (Basic / Niche)	Textiles appear in 2% of records. SMEs appear in under 2% of records. Food waste appears in 5% of records.	RQ7: Which sector constraints such as shelf life, hazard class battery health should models include? RQ8: How can small firms join reverse logistics?	Sector case studies; shared-facility models. The authors have seen that Sector coverage is uneven across industries.
5. Resilience (Basic – Waste)	Resilience such as medical waste became basic after 2021. 35% Of records handle uncertainty. 24 Records deal with epidemics.	RQ9: How should networks be redesigned to keep working during epidemics or supply shocks? RQ10: Is the rise of medical-waste research really caused by COVID-19?	Robust optimisation; backup-facility models. The authors have seen that Resilience is increasingly important but still limited.

Note: Percentages come from a keyword count on the title, abstract and keywords of the 727 Bib Tex records.

Reverse logistics optimisation is a field where there is clearly a technological heartland, yet the locus is still the mathematical model. Recent developments have found connections between optimisation and economy, medical waste, and cleaner transportation, but issues concerning digital technologies, customers, industry specifics, policy, and practical validation are weak. The priorities should be integrating prediction into optimisation, testing tools using real-life data, modelling the customer and social effects, designing robust networks, and measuring circularity.

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