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Review

Visualising the Knowledge Domain of Reverse Logistics and Sustainability Performance: Scientometric Mapping Based on VOSviewer and CiteSpace

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Abstract: Considering reverse logistics' benefit for sustainability, it has gained significant attention as a strategic decision. Additionally, a geometric expansion occurs in reverse logistics and sustainability performance. Despite this, little has been written about this evolution retrospectively. Therefore, this study aims to conceptualise and perform a systematic scientometric review of reverse logistics and sustainability performance to identify research hotspots and emerging trends and offer suggestions for future research agendas by reviewing, retrieving, and analysing 848 papers from the Scopus databases. Based on the analysis, there was a rapid rise in the number of publications within this domain, while, at the same time, increasing interdisciplinary subject research has appeared. Furthermore, scholars and institutions from China, India, and the USA were the most prolific in this research domain. Mainly, the current study underscored some pivotal research hotspots, such as assessing the reverse logistics effect on different sustainability performance dimensions and developing a reverse logistics and sustainability performance network. Moreover, emerging trends include game theory, artificial intelligence, Industry 4.0, the manufacturing industry of developing countries, and the circular economy. Finally, a moderator was also sought to be proposed to optimise the relationship between reverse logistics and sustainability performance due to the inconsistent link between them. Having a comprehensive overview of reverse logistics and sustainability performance over the last 24 years may help practitioners and researchers better understand global trends and directions in this field.

Keywords: sustainability performance; reverse logistics; scientometrics; CiteSpace; VOSviewer

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1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) reported that climate change in the form of global warming would increase to 1.5 °C in the coming decade, thus leading to increased heat waves and longer warm and shorter cold seasons [1]. Notably, 831 critical climate-related situations instigated a global economic loss worth USD 166 billion and 55.3 Giga tera (Gt) of carbon dioxide (CO_2) in the form of emissions in 2018, which is a new high [2]. These unfavourable environmental implications have caused grave concerns on a global scale. Sustainable organisations are urged to optimise their perceptions of sustainable development objective attainment related to social well-being, economic growth, and environmental conservation [3].

The term 'sustainability' denotes the ability of a generation to be self-sufficient without undermining the needs of future generations. Sustainability performance dimensions are inextricably linked to the triple bottom line (TBL) involving social, environmental, and economic performance [4]. Essentially, sustainability principal adoption potentially facilitates organisational profitability [5] and sustainability in the long run [6] with an emphasis on forward supply chain activities rather than reverse flows. Although the generic yet fundamental predictors and their additional counterparts are more inclined towards forward flows based on the Global Reporting Initiative guidelines [7], reverse logistics could substantially facilitate organisational sustainable initiatives [8].

As a logistics function with an emphasis on backward (customer-to-supplier) product flow, reverse logistics could achieve sustainability and gain a competitive edge for optimal profitability [5], minimal cost [9], and high customer happiness [10]. A well-managed reverse logistics allows industries to recapture values that would otherwise be lost. For example, a re-manufactured engine could substantially minimise emissions by 565 kg CO_2, 6.09 kg CO, and 3.98 kg SO_2, unlike a new engine with no re-manufactured products [11,12]. Additionally, the re-manufactured product retail price is generally from 50% to 70% lower than that of a new counterpart [13].

The Mathiyazhagan et al. [14] study showed that considering sustainable issues from a reverse logistics perspective may be a future research opportunity. Against this backdrop, several studies have been conducted to profile reverse logistics and sustainability performance studies. In these analyses, a variety of perspectives have been discussed. There have been a large number of papers and special journals addressing a wide range of topics, including the relationship between reverse logistics and sustainability performance, such as economic performance [15,16], environmental performance [17], and social performance [8]; the impacts of perceptions and reactions from stakeholders on reverse logistics and sustainability performance [18–20]; the effect of different disposition options of reverse logistics on sustainability performance [7,21,22]; evaluation of the effects of reverse logistics on sustainability performance using quantitative methods [18,23,24]; and comprehensive reviews of reverse logistics on sustainability performance [6].

However, the majority of reviews are expert-dependent and these subjective individual preferences result in a lack of quantitative bibliometric analysis in this field (e.g., analysis of words, authorships, citations, co-citations, co-occurrences). Despite a wide range of publications in the reverse logistics and the sustainability performance field, it is largely unknown how the intellectual landscape of these fields is structured.

As such, the objective of this study is to explore the evolution of scientific knowledge in the area of reverse logistics concerning sustainability. For this objective, this project will explore the links between this binomial to identify the most influential researchers and institutions, the research hotspots, the emerging trends, knowledge gaps, as well as future lines of research that will focus the attention of the research context in the years ahead. The following are the research questions in this paper:

- What is the chronological growth of publications on reverse logistics and sustainability performance?
- What are the influential contributors (countries, authors, institutions)?
- What are the hotspots of the research based on the citation burst of references?
- What are the most recent and emerging research frontiers regarding reverse logistics and sustainability performance?
- What are the latest and most promising research frontiers in reverse logistics and sustainability?
- What are the research gaps and what can be performed to advance it in the future?

In order to address these questions, the current study employed two bibliometric analysis instruments (VOSviewer and CiteSpace) to conduct a scientometric analysis of reverse logistics and sustainability performance for a holistic overview and comprehension of domain-related advancements. Especially, to our knowledge, despite the popularity of CiteSpace and VOSviewer, attempts have yet to be made to use CiteSpace and VOSviewer to analyse the literature on reverse logistics and sustainability performance.

In this paper, we present an intensive examination of the exponentially growing area of reverse logistics and sustainability performance, contributing to the literature on reverse logistics and sustainability performance. Specifically, the study identifies the bibliometric characteristics and visualises relationships of publications in the field of reverse logistics and sustainability performance over a specific period to provide a more systemic and objective analysis. The study goes beyond a mere literature review, which is not necessarily comprehensive, or meta-analyses that ignore connections between publications within a field [25]. As a result, the paper presents the reader with a thorough overview of the field by utilising the powerful machine learning-based capabilities of bibliometric tools and network analysis.

Based on the analysis of 848 studies of reverse logistics and sustainability performance, the study provides other researchers with four helpful contributions: (1) internalise research collaboration attributes in reverse logistics and sustainability performance; (2) determine highly cited authors, inscriptions, and journals in the domain; (3) depict primary research hotspots and the decades-long field evolvement; and (4) identify emerging reverse logistics and sustainability performance topics. Additionally, this study identifies the inconsistent relationship between reverse logistics and sustainability performance, providing the addition of a moderator to optimise the link in future qualitative studies. Lastly, this work summarised key outcomes and proposed future study directions that depict the broad applicability of this study.

2. Data Source and Search Strategy

2.1. Data Source

This study utilised the core collections derived from Scopus. The Scopus database was chosen because it is considered the biggest database, constituting abstracts and citations with 16 million author data and 1.4 billion citations, to ascertain its empirical nature and completeness [26]. Additionally, Scopus proves beneficial as it indexes 70% more sources than that of Web of Science [27] with holistic publications [28]. Thus, in order to cover more topics, the Scopus database was used as such topics may not be available in WoS or MedLine databases. Secondly, a wide range of related subjects is covered by Scopus, including psychology, social sciences, engineering, and business [29]. Lastly, the studies of Archambault et al. [30] and Bensalem et al. [31] indicated that the WoS and Scopus databases are robust tools for measuring science. However, the two databases have an extremely high correlation, in which some research may overlap [32].

2.2. Search Strategy

This review was conducted using the methodology described by Peron et al. [33] for sourcing documents on reverse logistics and sustainability performance. A detailed set of retrieval steps and corresponding results is shown in Figure 1, which was based on the PRISMA protocol [34].

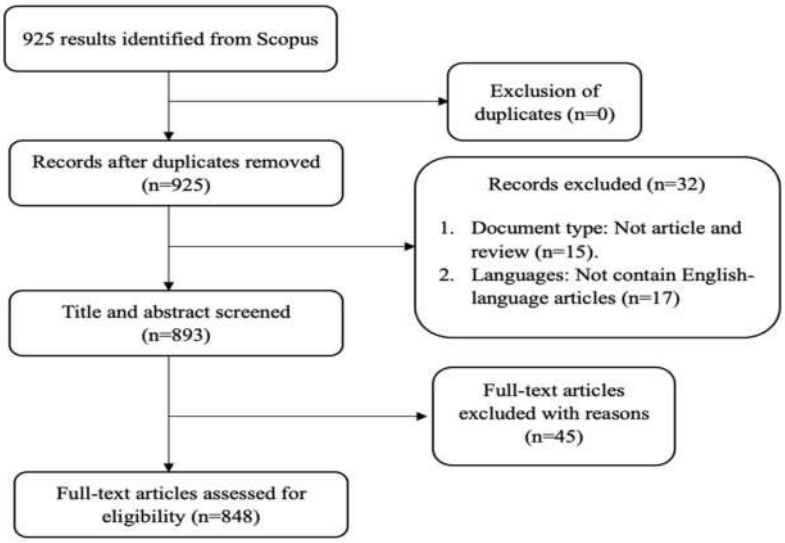

Figure 1. The process for selecting records.

As a first step, keywords were established for the selection of papers to identify potentially relevant articles; the used search terms, including "reverse logistics" or "reverse supply chain", "sustainability" or "sustainability performance", and "sustainable development", were then utilised to create search strings for the electronic databases. Notably, the keywords used in the literature search were based on the studies of Banihashemi et al. [6],

Alkahtani et al. [22], and Nobanee et al. [35]. Additionally, to prevent publications from being missed, six combinations of the initial search keywords were used, including (1) "reverse supply chain" and "sustainability performance", (2) "reverse supply chain" and "sustainability", (3) "reverse supply chain" and "sustainable development", (4) "reverse logistic" and "sustainability", (5) "reverse logistics" and "sustainable performance", and (6) "reverse logistic" and "sustainable development".

The search string of Scopus was:

Topic = (TITLE-ABS-KEY ("reverse logistics") OR TITLE-ABS-KEY ("reverse supply chain") AND TITLE-ABS-KEY (sustainability) OR TITLE-ABS-KEY ("sustainability performance") OR TITLE-ABS-KEY ("sustainable development")) AND (EXCLUDE (PUBYEAR, 1996)) AND (EXCLUDE (DOCTYPE, "ch") OR EXCLUDE (DOCTYPE, "le") OR EXCLUDE (DOCTYPE, "no") OR EXCLUDE (DOCTYPE, "bk") OR EX-CLUDE (DOCTYPE, "ed") OR EXCLUDE (DOCTYPE, "tb")) AND (LIMIT-TO (LANGUAGE, "English")) on 22 October 2022.

The initial selection was completed for 925 studies. Specifically, the data were retrieved from the Scopus database on 22 October 2022. Next, the screening process was completed on practical and methodological grounds pre-search to determine literary correlations [36]. All the studies were reviewed by reading the title and the abstracts to check their relevance. Additionally, in order to ensure the quality of publications, we delimited the peer-reviewed articles and books, proceeding papers, and other unpublished works based on the study of Bouazzaoui et al. [37]. A total of 910 records resulted from the query-based search approach. Meanwhile, 17 papers were found that unfulfilled the language requirement, which was mentioned in Table 1. In the end, after testing the relevance of the collected papers, 893 papers were considered to be valid.

Table 1. The 10 highly productive nations.

Rank	Country	Total Publications of a Given Country (TPc)	SCP (%)
1	China	122	72.1
2	India	118	66.9
3	The USA	90	47.8
4	Brazil	85	73.3
5	The UK	70	45.7
6	Iran	51	62.7
7	Italy	38	65.8
8	France	34	50.0
9	Malaysia	32	60.0
10	Australia	30	24.1

As a final step, an in-depth review of the full texts of these papers was conducted as part of the eligibility phase to evaluate the quantitative and qualitative quality. The studies, which only focus on sustainability performance or reverse logistics, will be excluded manually. Thus, we excluded them in the following bibliometric analysis and 848 papers were extracted finally.

3. Results and Discussion

3.1. Publication Output and Research Interest Growth

To summarise, 848 studies were published in the past 24 years (see Figure 2). The number of publications in distinctive periods was plotted in this study to perceive the evolvement of study interests. Following Figure 2, this topic demonstrated consistent growth from 1999 (oldest publication) to the 2000s. Reverse logistics-oriented studies for sustainability only emerged in 1999 despite the first official introduction of sustainability in 1987 by the United Nations Brundtland Commission [38]. The existing studies on reverse logistics emphasised three sustainability performance dimensions. Presley et al. [39] presented all three components (TBL) of reverse logistics [24]. A strong interest in reverse logistics and sustainability performance research was perceived in 2007 (see Figure 2) following the gradual rise of yearly publications and overall publications.

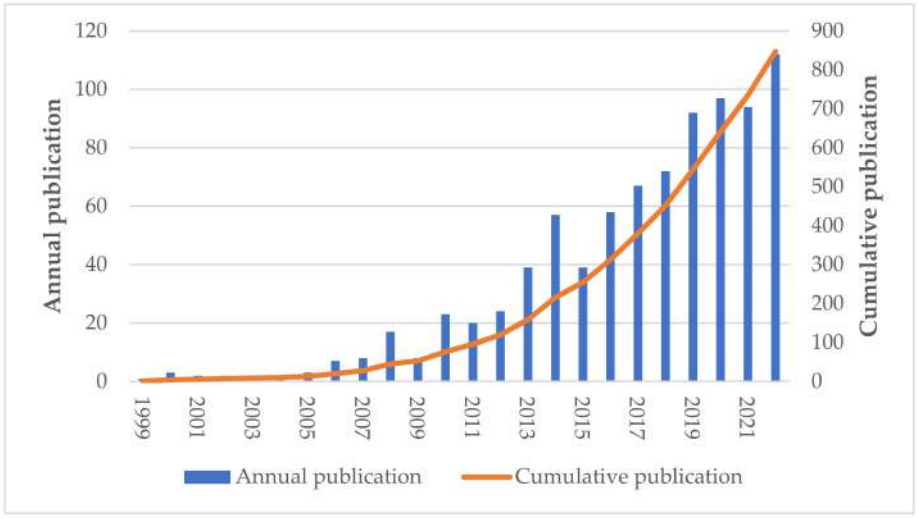

Figure 2. Distribution of articles over time.

Notwithstanding, this graph reflected a descending pattern with inconsistent figures in 2015 possibly due to a management fad [40]: the tendency for a business notion to gain popularity and revert to modest utilisation [31]. In 2016, there was a substantial rise in publications on the reverse logistics-sustainability performance link. This increase could have resulted from the SDGs and 2030 Agenda established in 2015 and the 2016 Paris agreement. Overall, reverse logistics and sustainability performance have gained much scholarly attention despite their relative novelty. Study domains involving the reverse logistics-sustainability performance correlation prove extensive with the active engagement of various global study groups. Nevertheless, most publications required users to subscribe for information access. Only 266 papers (31%) were open-access publications as of 2022. These papers could be highly cited if published through open-access journals.

3.2. The Collaboration Network of Reverse Logistics and Sustainability Performance

3.2.1. Country Collaboration Network

The top 10 nations (including Asian countries, such as China, India, Iran, and Malaysia) generating reverse logistics and sustainability performance studies on a global scale are illustrated in Figure 3. China and India, which generated approximately 30% of the worldwide publications, implied their role as key players in the scientific advancements of reverse logistics and sustainability performance. With 122 papers in 66 journals, which amounted to 14% of the global publications, China was the leading country followed by India, with slightly lower production.

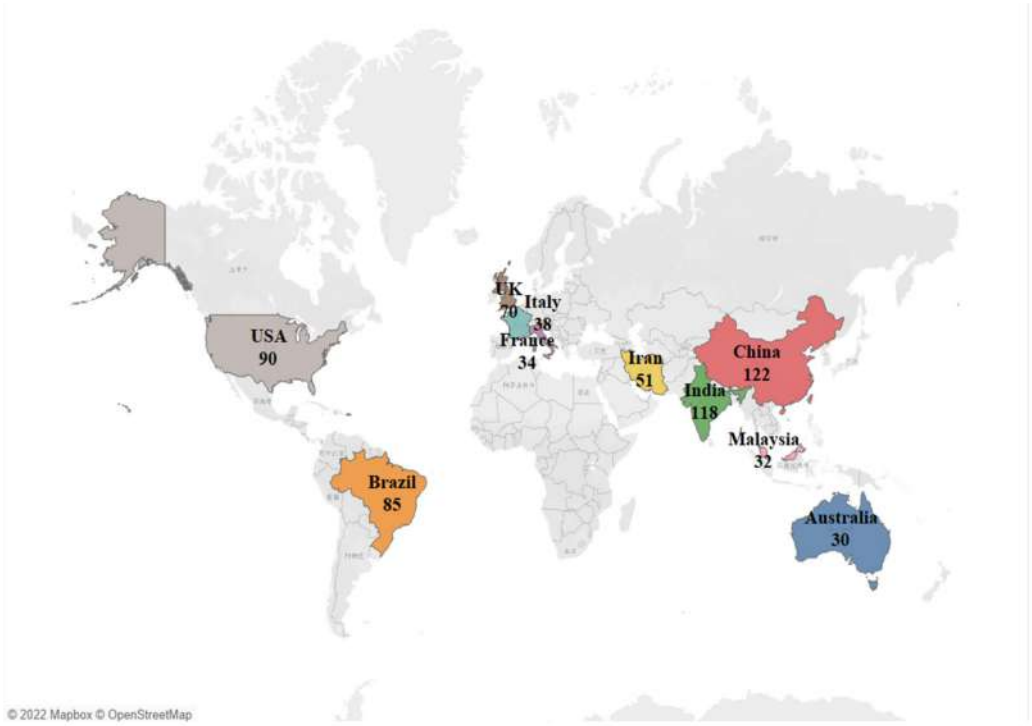

Figure 3. Visualisation of the 10 highly productive nations.

Only Brazil (73.3%), China (72.1%), and India (66.9%) generated over two-thirds of single-country publications (SCP) among the 10 aforementioned nations. The statistics implied a strong intra-country collaboration. Meanwhile, Australia denoted the lowest SCP (24.1%) with 22 out of 29 publications affiliated with 16 nations. The benefits reaped by this global collaboration are not restricted to network expansion and knowledge and expertise sharing but include optimal rank-elevation strategies. For example, 52.2% (47 papers) of its publications in the USA (third-most productive nation) denoted global collaborative papers affiliated with 23 nations.

Figure 4 primarily depicts the distribution of nations or territories per region. The country collaboration network constituted 59 nodes and 195 connections from 1999 to 2022. Notably, the close proximity of two nations in VOSviewer indicates the strength of their correlation and the link between both countries with a thicker line [20]. The outcomes elicited from the co-authorship demonstrated the UK, which was associated with 25 nations or territories and 50 instances of co-authorship, as the most affiliated nation, followed by India (23 links, 51 co-authorships), the USA (22 connections, 59 co-authorships), China (20 connections, 49 co-authorships), and Australia (16 connections, 28 co-authorships). Undeniably, Asian nations significantly influence intra-country collaborations. Such co-operative relationships have been established among the 10 countries since 2010 based on the coloured line. Additionally, the thinness of the links between nations denoted low collaboration levels. Only the Algerian scholars were not affiliated with any other nation to publish empirical works on the reverse logistics-sustainability performance connection.

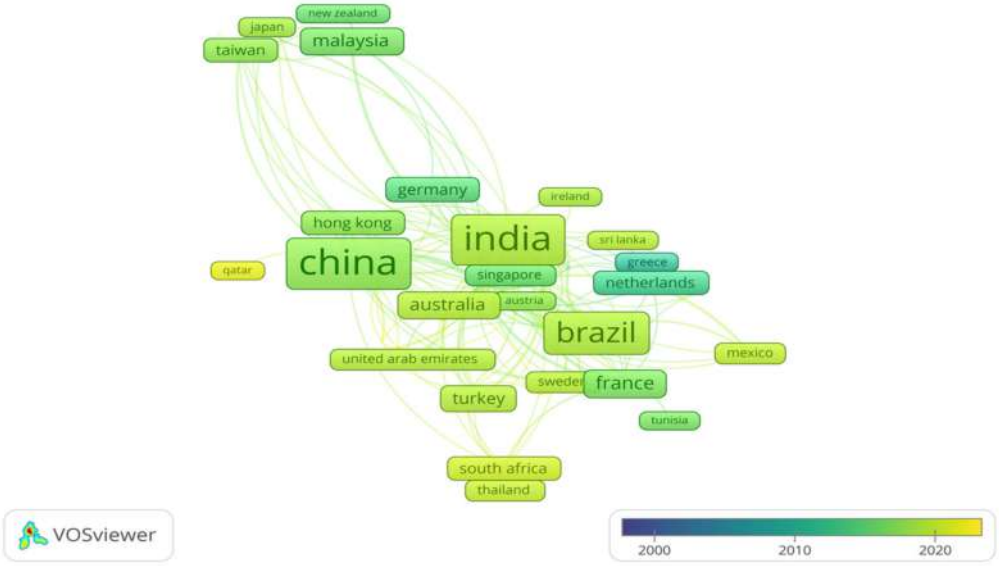

Figure 4. Visualisation of country collaboration network.

A flexible yet grounded research policy proves necessary in determining sustainable international collaborations given the high diversity of research partners, percentage of international postgraduates or visiting scholars, and research funding resulting from the dynamics of international collaborations [41].

3.2.2. Institution Collaboration Network

This network encompassed 916 institutions and 335 collaboration links from 1999 to 2022 (see Figure 5) with the University of Southern Denmark ranked first (26 out of 29 articles). Notably, this academic institution is deemed most productive in examining reverse logistics and sustainability performance within Denmark, followed by Islamic Azad University (16), Universiti Malaya (14), Indian Institute of Technology (13), and University Plymouth (12). Malaysia denotes the largest contributor to reverse logistics and sustainability performance studies with two institutions: Universiti Malaya and Universiti Sains Malaysia (ranked 3rd and 6th, respectively). Both institutions were one of the first to develop collaborative ventures following the link colour. All 10 productive institutions, which belonged to universities, indicated the global attention received by reverse logistics and sustainability performance (Table 2).

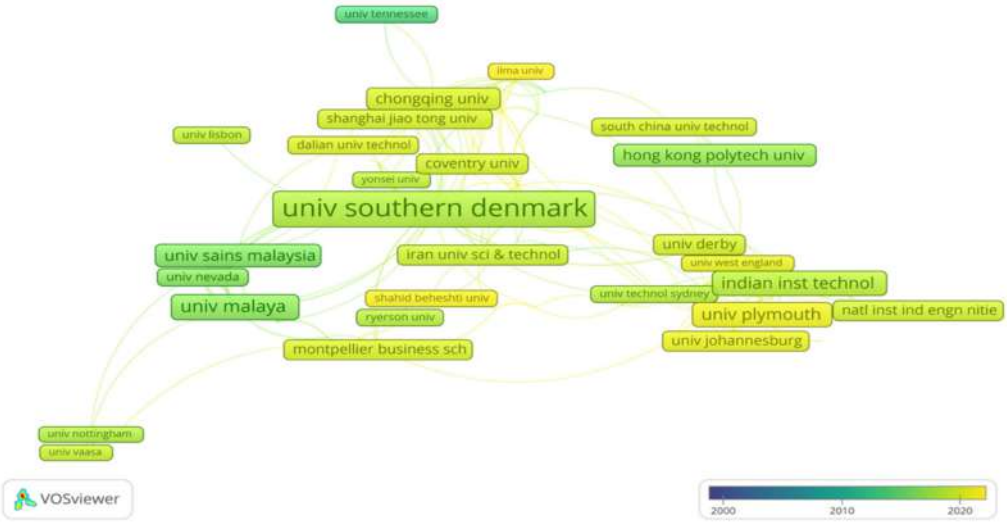

Figure 5. Visualisation of institution collaboration network.

Table 2. The 10 institutions based on frequency.

Institution	Country	Frequency
University of Southern Denmark	Denmark	26
Islamic Azad University	Iran	16
Universiti Malaya	Malaysia	14
Indian Institute of Technology	India	13
University Plymouth	United Kingdom	12
Universiti Sains Malaysia	Malaysia	11
Chongqing University	China	10
Hong Kong Polytechnic University	China	10
Indian Institutions of Management	India	9
Montpellier Business School	French	9

3.2.3. Author Collaboration Network

Figure 6 depicts the collaborative rapport among scholars and productive scholars in the largest subnetwork, thus facilitating reverse logistics and sustainability performance studies. Notably, the collaboration network encompassed 2077 authors and 80 collaboration links.

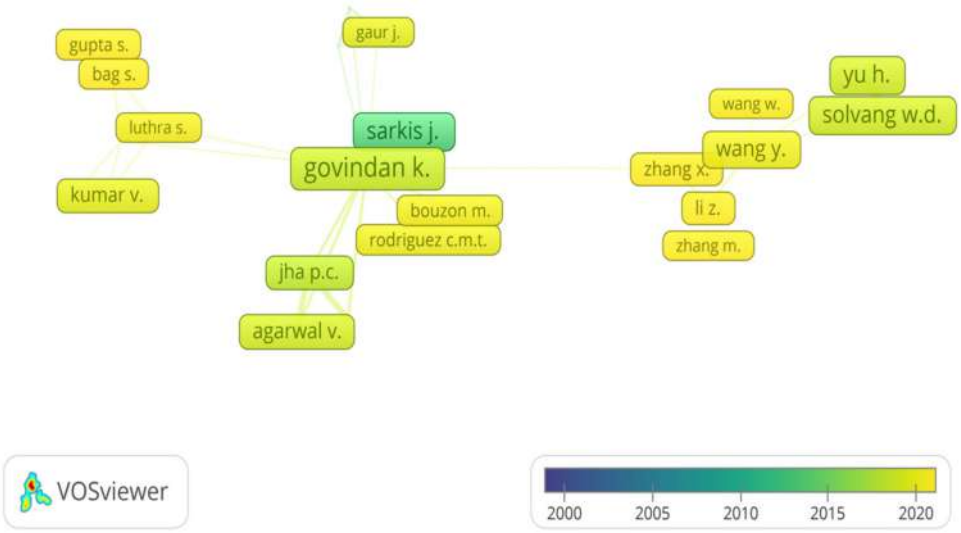

Figure 6. Visualisation of author collaboration network.

As the most affiliated academic linked to 12 authors, Govindan Kannan has collaborated with University of Southern Denmark (see Table 3) and frequently contributed to empirical works on reverse logistics and sustainability performance. Hence, collaboration potentially generates a high number of publications. Based on Sarkis Joseph's co-authorship outcomes, which could validate the current study finding, the author published the first article on reverse logistics and sustainability performance in 2001, which is 13 years earlier than that of Govindan Kannan. Regardless, Sarkis Joseph's total number of publications is lesser than that of Govindan Kannan. In Figure 5, Sarkis Joseph, who developed a closer relationship since 2010, was only affiliated with one academic. Following the multitude of yellow-coloured links between these authors, broad-ranging partnerships were established in 2015.

Table 3. List of the 10 most prolific authors.

	Author	Year of First Publication	TP	Current Affiliation
1	Govindan, Kannan	2014	14	University of Southern Denmark, Odense, Denmark
2	Solvang, Wei Deng	2013	8	UiT Norges Arktiske Universitet, Tromso, Norway
3	Yu, Hao	2013	8	UiT Norges Arktiske Universitet, Tromso, Norway
4	Sarkis, Joseph	2001	8	Worcester Polytechnic Institute, Worcester, United States
5	Singh, Rajesh Kumar P.	2015	8	Indian Institutions of Management, Gurgaon, Gurugram, India
6	Wang Yan	2010	8	University of Brighton, Brighton, United Kingdom
7	Agarwal, Vernika	2015	7	Amity University, Noida, India
8	Darbari, Jyoti Dhingra	2015	7	Lady Shri Ram College for Women, New Delhi, India
9	Agrawal, Saurabh	2015	7	Delhi Technological University, New Delhi, India
10	Jha, Prakash C.	2015	6	University of Delhi, New Delhi, India

The relatively loose author collaboration network structure with a low number of close relationships characterised the lack of strong collaborative connections and maturity among author groups and research communities.

3.3. The Co-Citation Network of Reverse Logistics and Sustainability Performance

3.3.1. Document Co-Citation Network (DCN)

The network was generated using CiteSpace with title terms and a log-likelihood ratio (LLR) weighting algorithm for computing and determining every label type and present the core cluster concept with professional words for cluster labelling; DCN encompassed 845 cited references and 2809 co-citation links from 1999 to 2022 (see Figure 7). For example, the blue-coloured area at the upper-left quadrant, labelled as the #14 multiple stakeholder perspectives, implied that Cluster #14 was cited by studies on numerous stakeholder viewpoints.

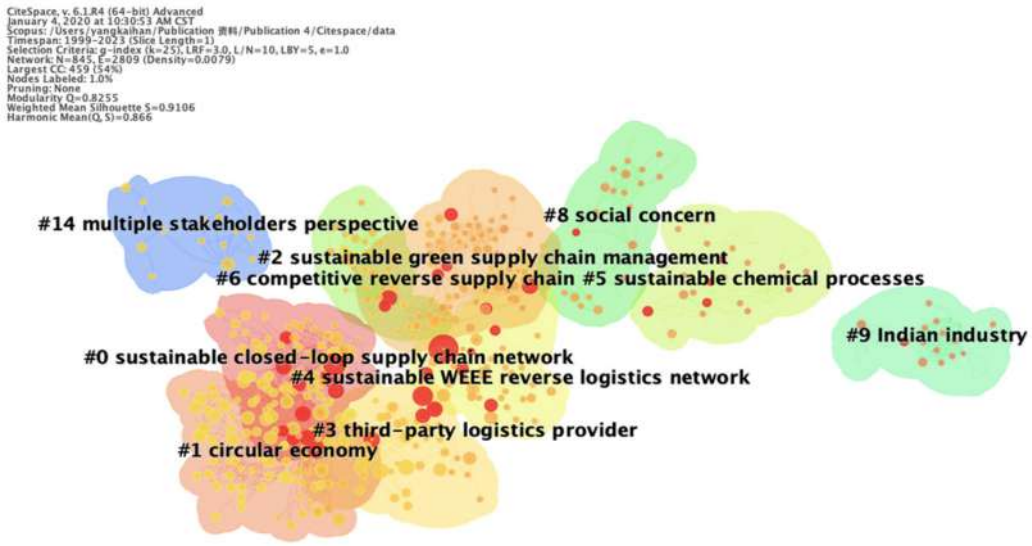

Figure 7. Visualisation of DCN.

The relatively high network modularity (0.8255) denoted the definition of science mapping specifications regarding co-citation clusters. As a predictor of homogeneity or consistency for cluster quality assessment, the largest 10 clusters' silhouette score exceeded 0.8, thus implying optimal quality following the proximity to the highest value (1.00) following Table 4. Specifically, the current review focused on an adequately high number of major clusters.

Table 4. Cluster summary.

Cluster ID	Size	Silhouette Score	Label (LLR)	Mean (Average Year)
0	76	0.847	Sustainable closed-loop supply chain network (159.48)	2017
1	76	0.892	Circular economy (279.77)	2018
2	75	0.889	Sustainable green supply chain management (123.83)	2013
3	52	0.924	Third-party logistics provider (82.76.48)	2016
4	42	0.917	Sustainable WEEE reverse logistics network (77.5)	2013
5	40	0.942	Sustainable chemical processes (83.99)	2009
6	30	0.932	Competitive reverse supply chain (105.52)	2015
8	28	0.963	Sustainable reverse logistics system (62.78)	2011
9	25	0.997	Indian industry (47.17)	2013
14	15	0.981	Multiple stakeholder perspectives (55.91)	2017

Table 4 presents 10 primary clusters based on the number of members (size) in each one. Clusters with few members are less representative than their larger counterparts given the propensity of small clusters to be formed by the citing behaviour of a small number of publications. The two largest clusters, #0 sustainable closed-loop supply chain network and #1 circular economy, encompassed 76 member references that are slightly bigger than other clusters. Moreover, the average publication year of a cluster implies its recency. Cluster #1, the most recently established cluster on CE, depicted the average year of 2018, thus outlining the relative novelty of most clusters. On another note, the #5 sustainable chemical processes denote an older issue following the mean cite year regarding every cluster.

Ten of the most highly cited articles by co-citation frequency, which are typically considered landmarks following significant breakthroughs [42,43], are presented in Table 5. Such works have been undeniably significant in developing reverse logistics and sustainability performance studies owing to their high citation frequency [44]. For example, four of Govindan Kannan's publications belong to the top 10 landmarks. One of his articles published in 2010 reflected the highest centrality at 0.06. Overall, Govindan Kannan's articles are deemed as a landmark within the broadly defined area of reverse logistics and sustainability performance as the betweenness centrality of a network node evaluates the significance of the node position in the network.

Four of the articles in the top 10 landmarks, which demonstrated three significant features to develop a reverse logistics network under sustainability (low environmental implications and high degree of social accountability and organisational economic motivations), originated from cluster #0 [45,46]. Govindan et al. [45], who integrated reverse logistics and sustainability, introduced a sustainable reverse logistics model to mitigate environmental effects and enhance social responsibility. Meanwhile, Govindan and Soleimani [47] emphasised the three following sectors: auto parts suppliers, vehicle manufacturers or remanufacturers, and electronics and computers. In line with the current research, products with low reusing designs led to a loss-making reverse supply chain and rendered reverse logistics or closed-loop supply chain an inevitable concern due to regulations.

Based on the four articles (two each from clusters #2 and #3) among the top 10 landmarks, the two publications from cluster #2 demonstrated that implementing green, sustainable, and environmental goals could navigate future green supply chain works [48,49]. Zarbakhshnia et al. [49] also affirmed the notable lack of social elements in (model-based) sustainable supply chain management studies. Meanwhile, the two articles under cluster #3, which entailed third-party reverse logistics selection and assessment for sustainability performance, primarily emphasised the selection of third-party logistics providers. Most companies prefer incorporating the resources into core organisational competencies and fully or partially outsource reverse logistics processes to third-party providers following these reverse logistics intricacies and differentiators [50]. For example, companies select third-party reverse logistics provider collaborations to address governmental, regulatory, and consumer pressure for social, environmental, and economic performance goal attainment [50,51].

Clusters #1 and #6 constitute one article each. Following the cluster #6 article, sustainable competitiveness has compelled organisational optimisation by adopting reverse

logistics practices. Meanwhile, the cluster #1 counterpart emphasised circular economy (CE): a suitable waste management method that internalises and incorporates radically new patterns and facilitates social sustainability and welfare at minimal or zero material, energy, and environmental costs [52].

Table 5. The 10 highly cited papers with co-citation frequency.

Rank	Citation Counts	Centrality	References	Cluster
1	54	0.01	Govindan et al. [48]	2
2	41	0.03	Govindan and Soleimani [47]	0
3	19	0.06	Govindan et al. [45]	0
4	19	0.01	Govindan and Bouzon [46]	1
5	16	0.01	Agrawal et al. [53]	6
6	15	0.01	Ghisellini et al. [52]	1
7	14	0.02	Bai and Sarkis [54]	3
8	14	0.02	Brandenburg et al. [50]	2
9	14	0.00	Zarbakhshnia et al. [49]	0
10	13	0.02	Senthil et al. [51]	3

3.3.2. Author Co-Citation Network

The outcomes derived from this section present highly cited authors. In this analysis, all the articles authored by a specific scholar were integrated into one entity, where only the first author is regarded. Figure 8 depicts the merged author co-citation network with 927 nodes and 3370 co-citation links expanding the body of knowledge on reverse logistics and sustainability performance. Specifically, Govindan Kannan, Moritz Fleischmann, Dale Rogers, VDR Guide, and Samir K Srivastava were the five most highly cited authors with 233, 168, 159, 113, and 111 citations, respectively.

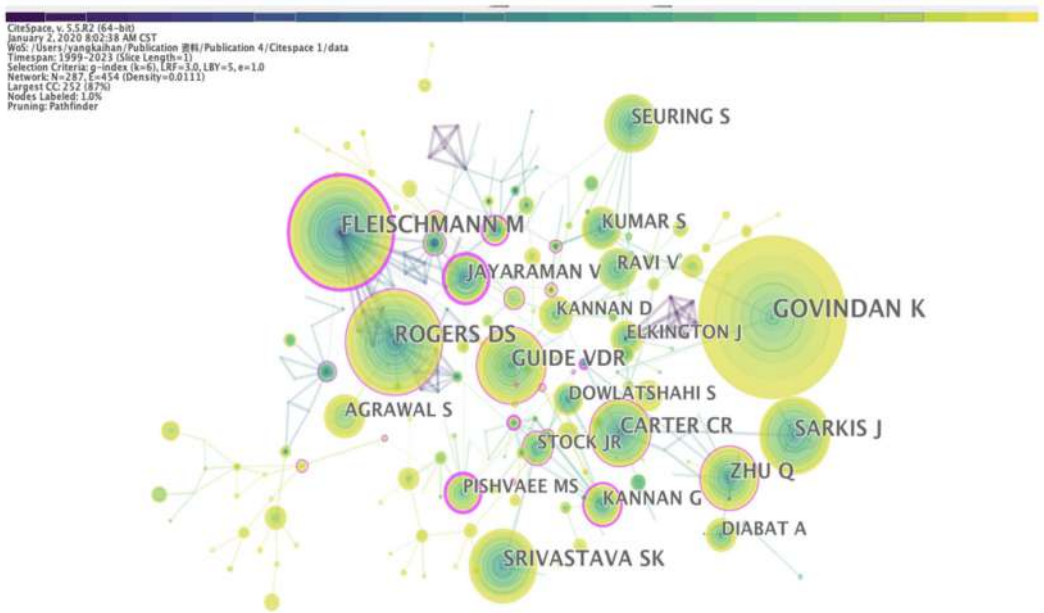

Figure 8. Visualisation of author co-citation network.

Kannan Govindan's study areas primarily include reverse logistics, CE, and sustainable supply chain management (see Table 6). On another note, Moritz Fleischmann is a seeded second despite not being a sustainability performance researcher. As such, the contributions made by such highly cited authors significantly affect the development of reverse logistics and sustainability performance despite not being experts in the study area.

Table 6. The 10 highly cited authors with co-citation frequency.

Rank	Author	Count	Centrality	Research Area
1	Govindan, Kannan	233	0.03	reverse logistics; CE
2	Moritz Fleischmann	168	0.52	reverse logistics; supply chain management
3	Dale Rogers	159	0.19	sustainability; reverse logistics
4	Sarkis Joseph	117	0.04	sustainability; green practices
5	VDR Guide	113	0.10	closed-loop supply chain; sustainable operations; remanufacturing
6	Samir K Srivastava	111	0.05	reverse logistics; sustainable supply chains
7	Craig R. Carter	100	0.21	supply chain management; sustainability
8	Qinghua Zhu	94	0.08	green supply chain; corporate social responsibility; re-manufacturing
9	Stefan Seuring	88	0.12	sustainable supply chain management
10	Agrawal Saurabh	71	0.08	closed-loop supply chain; re-manufacturing; reverse logistics; sustainable development

Both Kannan Govindan and Moritz Fleischmann represented key network nodes following the high betweenness centrality linked to the transformative potential of an empirical contribution. The betweenness centrality nodes, which are no less than 0.1, are encircled in purple. Parallel to past research, such nodes potentially determine boundary-spanning potentials that may induce transformative discoveries [38].

3.3.3. Journal Co-Citation Authors

The journal-level co-citation network (see Figure 9) functions to depict the set of journals that serve the reverse logistics and sustainability performance research community in the past 24 years. A total of 734 different journals depicted a diverse body of literature that impacted reverse logistics and sustainability performance-oriented works. Table 7 presents 10 journal sets with co-citation frequencies exceeding 280. The Journal of Cleaner Production was highly cited with 623 co-citations, followed by the *International Journal of Production Economics* (574) and the *European Journal of Operational Research* (492). Observably, journals with a high CiteScore may demonstrate higher quotation frequencies as CiteScore potentially impacts some authors' decision to choose journals that complement unique studies [41]. Regarding the betweenness centrality (nodes encircled in purple) of cited journals, *Computers & Industrial Engineering* depicted the highest BC ratio at 0.14. Meanwhile, *Resources, Conservation and Recycling* demonstrated a high relative betweenness centrality ratio at 0.12. Both journals constitute core nodes that interconnect with other counterparts in the reverse logistics and sustainability performance research journal co-citation network.

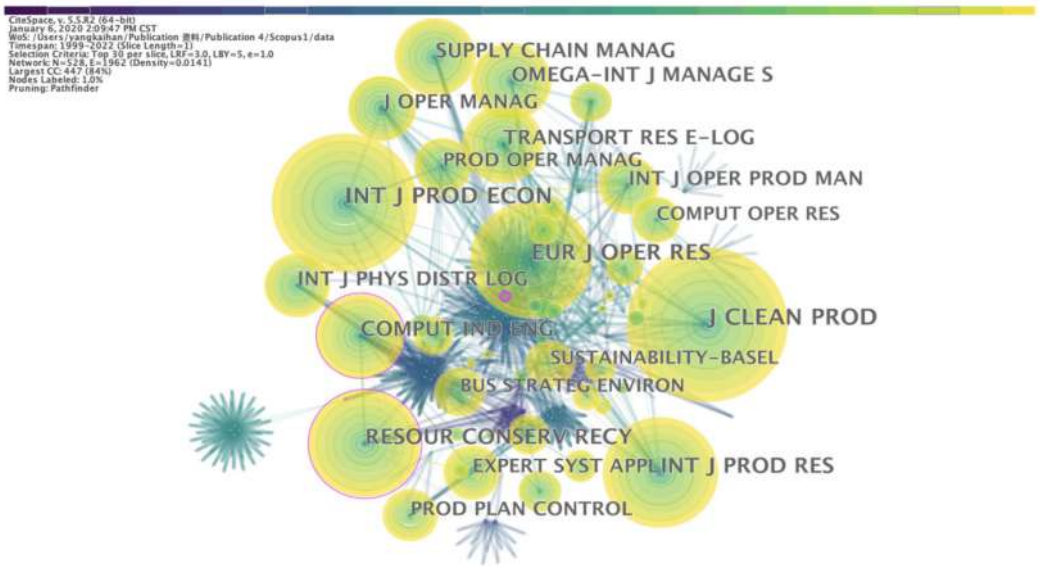

Figure 9. Visualisation of journal co-citation network.

Table 7. The 10 highly cited journals with co-citation frequency.

Rank	Journal	Count	Centrality	CiteScore 2021
1	*Journal of Cleaner Production*	623	0.02	15.8
2	*International Journal of Production Economics*	574	0.01	14.3
3	*European Journal of Operational Research*	492	0.03	10.5
4	*International Journal of Production Research*	469	0.03	14.6
5	*Resources, Conservation and Recycling*	447	0.12	17.9
6	*Computers & Industrial Engineering*	360	0.14	9.7
7	*Journal of supply chain management*	340	0.02	13.4
8	*OMEGA—The International Journal of Management Science*	337	0.06	11.5
9	*Transportation Research Part E: Logistics and Transportation Review*	336	0.03	11.6
10	*Journal of Operations Management*	280	0.01	8.8

Table 8 presents the 10 most prolific reverse logistics and sustainability performance journals that published 235 papers, thus accounting for 27.71% of the overall records. Such proliferation reflected field progress and high concentration. Notably, the 10 highly cited journal sources, such as the *Journal of Cleaner Production*, *International Journal of Production Economics*, *Resources, Conservation and Recycling*, *International Journal of Production Research*, and *Computers & Industrial Engineering* overlapped to some degree. The pluralistic nature of these journals, which incorporate environmental sciences, engineering, operations research, business, and management implied reverse logistics and sustainability performance as an interdisciplinary academic field. Following Tables 7 and 8, the journals with high effective factors could depict higher co-citation frequencies but highly prolific reverse logistics and sustainability performance research journals may not necessarily demonstrate a bigger impact.

Table 8. List of the 10 most prolific journals.

Rank	Journal	TP	Cite Score 2021
1	*Journal of Cleaner Production*	79	15.8
2	*Sustainability*	53	5.0
3	*Resources Conservation and Recycling*	17	17.9
4	*International Journal of Production Economics*	16	14.3
5	*Waste Management*	16	13.5
6	*International Journal of Production Research*	15	14.6
7	*Computers Additionally, Industrial Engineering*	11	9.7
8	*International Journal of Logistics Systems and Management*	9	1.9
9	*Waste Management and Research*	9	5.9
10	*International Journal of Physical Distribution and Logistics Management*	8	11.4

3.4. Disciplinary-Level Research Trends

A dual-map overlay denotes an analytical method that illustrates domain-level citation concentration with their reference paths [55], whereas a base map outlines interrelations of over 10,000 publications that are classified into specific regions that represent domain-level publications and citation activities [56]. Figure 10 illustrates the dual map overlay of opinion mining research. The left clusters in the visual representation (research fronts) represent the publication place of the retrieved records, whereas the right ones imply the citation place. Furthermore, the regions were labelled by the well-known terms identified in the journals. The thickness of these citation trajectories, which were distinguished by citing the colours assigned to the regions, parallels the z-score-scaled citation frequency. Notably, patterns of how published articles in opinion mining imply other intellectual bases (cited references) could be identified through this map. Five primary citation paths were highlighted in the study dataset following Figure 10. Table 9 summarises the aforementioned paths using citing and cited region names.

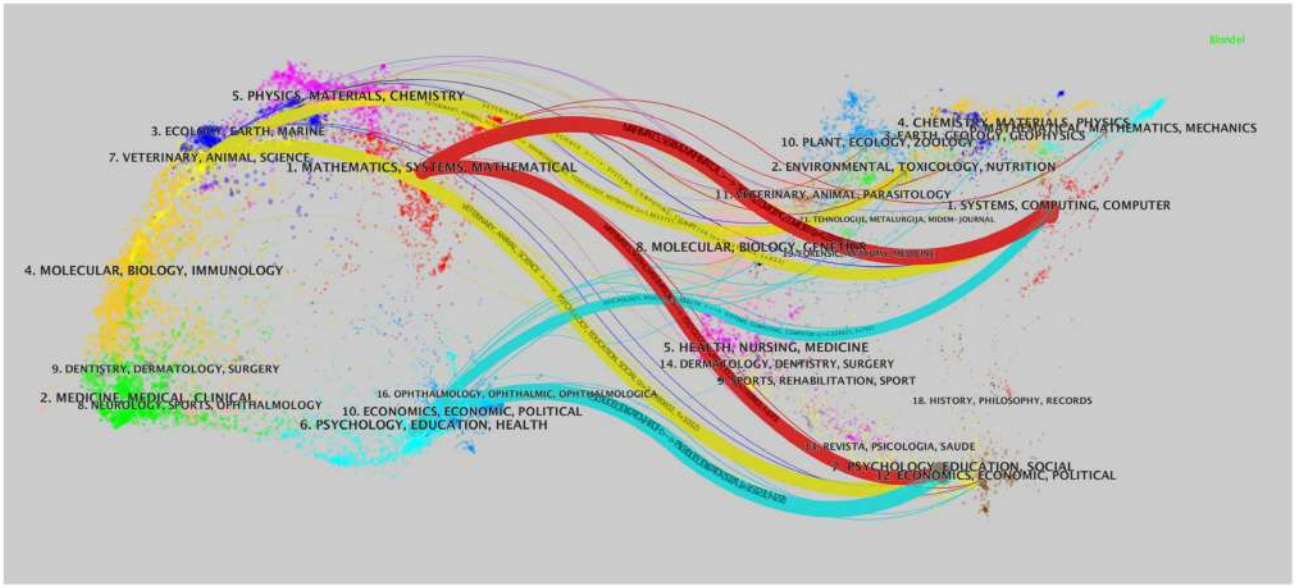

Figure 10. Domain-level citation patterns.

Table 9. Domain-level citation trends.

Citing Region	Cited Region	Z-Score
Mathematics, systems, mathematical	Systems, computing, computer	4.227
Psychology, education, health	Psychology, education, social	3.631
Mathematics, systems, mathematical	Psychology, education, social	2.919
Veterinary, animal, science	Psychology, education, social	2.738
Veterinary, animal, science	Systems, computing, computer	2.125

These relationships were grouped by the z-scores in descending order with values rounded to the closest thousandth. Every row was provided with the same colour as the corresponding path (see Figure 10). Studies on reverse logistics and sustainability performance mainly appeared in three broad areas on the citing map following Table 9: the red area at the top with the label 'mathematics/systems/mathematical'; the blue area at the bottom with the label 'psychology/education/health'; and the yellow area in the middle with the label 'veterinary, animal, science'. The citation curves stemming from each of the aforementioned regions indicated cited map regions on the right. Primary destination regions for citations with the reverse logistics and sustainability performance origin involved systems/computing/computer and psychology/education/social.

Meanwhile, the purple-lined 'ecology/earth/marine', yellow-lined 'molecular/biology/immunology', and green-lined 'medicine/medical/clinical' labels facilitated the domain-level citation trends in reverse logistics and sustainability performance works. Perceivably, such studies were partially multi- and monodisciplinary. Rows three and four in Table 10 that outlined an interdisciplinary attribute highlighted the reliance of mathematics, systems, and mathematical investigations in reverse logistics and sustainability performance on the following areas: psychology, education, and social.

Table 10. The 10 references with the strongest citation bursts.

References	Strength	Begin	End	1999–2022
Carter and Easton [57]	4.6	**2013**	2016	
Amin and Zhang [58]	3.51	**2015**	2017	
Govindan et al. [48]	5.78	**2016**	2020	
Brandenburg et al. [50]	4.21	**2016**	2019	
Eskandarpour et al. [59]	4.49	**2017**	2019	
Agrawal et al. [53]	4.42	**2017**	2020	
Cucchiella et al. [60]	3.26	**2017**	2018	
Mangla et al. [61]	3.27	**2018**	2020	
Govindan and Soleimani [47]	8.27	**2019**	2022	
Sahebjamnia et al. [62]	4.35	**2020**	2022	

3.5. Emerging Reverse Logistics and Sustainability Performance Research Trends

3.5.1. References with Citation Bursts

With regard to publications that have obtained a sharp rise in citations, citation bursts could partially depict the field dynamics. The 10 leading references with the most significant citation bursts (see Table 10) characterise significant milestones in reverse logistics and sustainability performance research developments and evolution. Observably, the earliest citation burst began in 2013 parallel to that of most authors' collaborations on reverse logistics and sustainability performance studies.

The emphasis on these major milestones between 2013 and 2022 is summarised in Table 10. For example, scholars regarded reverse logistics as a systematic means of elevating sustainability performance [48,50,57,61], assessing the key determinants of reverse logistics implementation [53,61], analysing the reverse logistics implications on various sustainability performance factors involving the environment, society, and economy [47,60], establishing a reverse logistics and sustainability performance network [62], and choosing the best reverse logistics supplier for sustainability development [58]. Regardless, citation bursts could determine specific nodes (cited references) as a temporal metric, which has garnered much scholarly interest in specific periods [55]. As a popular study focus, the reverse logistics effect on distinctive sustainability performance dimensions and the development of a reverse logistics and sustainability performance network continue bursting from the end to the present time of citation bursts.

3.5.2. Keyword Analysis

A time-zone view of keywords (see Figure 10) demonstrated the evolvement of the reverse logistics and sustainability performance base from 1999 to 2022 to thoroughly examine the study direction. The keywords in this visualisation view were arranged parallel to their publication or peak time. A time-zone view denotes a range of vertical strips as time zones, which are chronologically arranged from left to right so that a research front points back to its intellectual base. The slice length of CiteSpace was set to 5 with the top 30 references in each slice chosen for time-zone visualisation development. Essentially, this work summarised the primary outcomes derived from the time-zone view on reverse logistics and sustainability performance studies based on three major topics.

1. Terminology and concept

Sustainable development was the most frequently encountered keyword with 440 occurrences (see Figure 10). Perceivably, sustainable development co-occurred with conceptual keywords (excluding reverse logistics), such as reverse supply chain and closed-loop supply chain in reference to reverse logistics for sustainability performance development. The previously mentioned terms were related to reverse logistics. In Govindan et al. [48],

the resulting network would develop a closed-loop supply chain by simultaneously regarding forward and reverse supply chains. Although reverse logistics is a critical issue in practice, the current loop should be closed to optimise closed-loop supply chain management. Bensalem and Kin [31] highlighted the inextricable link between reverse logistics and the closed-loop supply chain with a fuzzy border. Furthermore, Govindan et al. [45] and Sahebjamnia et al. [62] depicted a potential correlation between closed-loop supply chains or reverse logistics and sustainability performance. Following Bensalem and Kin [31] research, reverse logistics and reverse supply chain were utilised for the similar search terms employed in article selection.

2. The impact of reverse logistics on sustainability performance

A time-zone view provides a sound comprehension and overview of the evolvement of the reverse logistics-sustainability performance link. Figure 11 illustrates the initial emphasis placed by reverse logistics on the environmental factor of sustainability performance. Carter and Ellram [63] defined reverse logistics as an organisational process that becomes environmentally efficient, thus applying an environmental focus to reverse logistics. Rogers and Tibben-Lembke's [64] connotation in 1999 added the double intention of creating business and environmental value from reverse logistics processes, which highlighted the debate over the economic advantages of reverse logistics. Based on Banihashemi et al.'s [6] study, no articles on the examination of the reverse logistics-sustainability performance relationship were published between 1990 and 2004. Additionally, research on reverse logistics with an emphasis on TBL performance remained scarce (see Figure 11). Most papers emphasised the correlation between reverse logistics and one or two sustainability performance dimensions. For example, Presley et al. [39] presented all three TBL components with regards to reverse logistics. Sarkis et al. [8] further denoted the reverse logistics role in attaining organisational TBL performance goals. A peak was identified in 2010 when multiple articles were published parallel to the output pattern of reverse logistics on sustainability performance (see Figure 2).

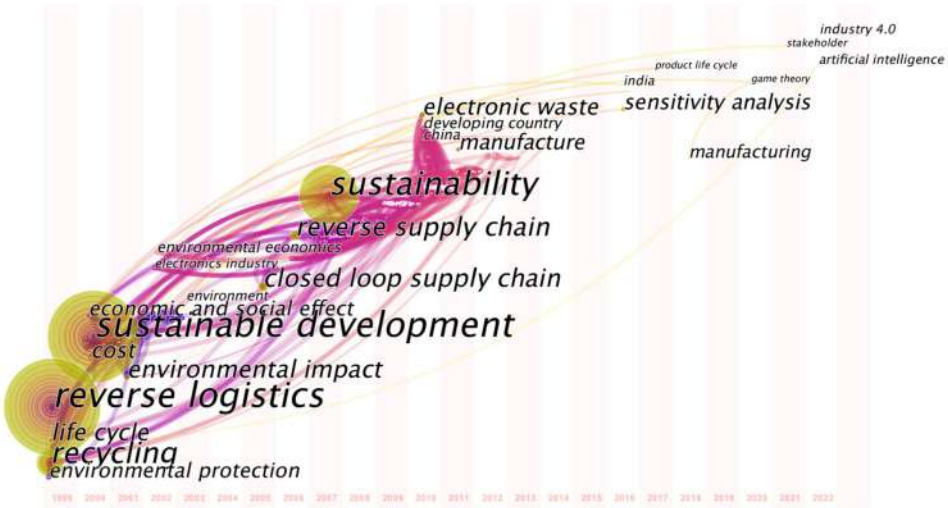

Figure 11. Time zone view of keywords.

3. The distribution of reverse logistics on sustainability performance

The empirical interest in specified domains could also be assessed based on the strength of the connection between two keywords. Most of the publications associated with electronic waste (48 papers) originated from the manufacturing sector (52 papers) in emerging nations (12 papers), including China (10 papers) and India (7 papers). As one of the primary industrial waste producers and environmental polluters, the manufacturing industry inevitably threatens environmental sustainability [65]. For example, the rising amount of electronic waste poses a social concern following the imminent risk of ecosystem

contamination from hazardous product substances [66]. Multiple reverse logistics practices have been promoted on a global scale to catalyse sustainable development [67], specifically electronic waste recycling [66]. Regardless, the implementation of approaches varied between developed and emerging countries owing to variances in economic progress. Jia et al. [68] revealed the challenges of implementing reverse logistics through TBL performance in emerging nations (Pakistan, India, Brazil, and Indonesia) compared to their developed counterparts. Consequently, empirical assessments on reverse logistics and sustainability performance in electronic manufacturing industries should be performed across emerging nations.

4. Emerging topics of interest on reverse logistics and sustainability performance

The novel incorporation of reverse logistics and sustainability performance, such as artificial intelligence, Industry 4.0, and game theory in some domains (see Figure 11) could be extensively examined in future works. For example, integrating Industry 4.0 initiatives with supply chain activities could elevate organisational sustainability performance [69,70]. Potential scholars could also provide a holistic internalisation of reverse logistics and sustainability performance by incorporating artificial intelligence and Industry 4.0. Explorations on the complexities underlying reverse logistics implementation for sustainability performance development through artificial intelligence and Industry 4.0 would also prove intriguing.

4. Conclusions and Limitation

4.1. Main Finding and Discussion

The current work utilised core Scopus collections to centrally integrate reverse logistics and sustainability performance literature as a data source, fully integrate the benefits of CiteSpace and VOSviewer (bibliometric visualisation software), and visualise the reverse logistics and sustainability performance domain analysis between 1999 and 2022. First, a preliminary analysis of the reverse logistics and sustainability performance research was performed based on the field development patterns. Regarding the knowledge topic recognition and evolution path analysis of the study field, this research examined the research hotspots and frontiers in the last 24 years. Lastly, the current work identified regular and future development patterns to provide a reference and basis for empirical development by organising the overall field development path. Specifically, several conclusions could be drawn from the outcomes.

The increase in researchers' output following publication data between 1999 and 2022 implied the empirical prominence of reverse logistics and sustainability performance. In the past seven years, these publications portrayed an ascending pattern that may be associated with the United Nations policy. China is the most productive country in terms of reverse logistics and sustainability performance research, followed by India and the USA. All the aforementioned nations encompassed highly productive authors and academic institutions. Furthermore, the most productive establishments and scholars originate from universities. Govindan Kannan, the most productive scholar with links to 12 authors, was employed at the most productive institution: the University of Southern Denmark. In this vein, collaboration potentially generates a higher number of publications. Asian nations also play pivotal roles in stable cooperative relationships that have been gradually established since 2010.

Highly influential authors are generally productive. Likewise, a high-level conformance relationship was identified between highly cited and prolific journals. Academic influence and highly cited works constitute the knowledge base in reverse logistics and sustainability performance. With regards to study topics, 10 clusters were determined in the topic clustering map associated with primary reverse logistics and sustainability performance topics in the last 24 years. Perceivably, CE also established the study interest and frontier of reverse logistics and sustainability performance. Reverse logistics and sustainability performance research has become interdisciplinary based on the disciplinary-level study patterns in this field.

This study offered an empirical overview of reverse logistics and sustainability performance works. Emerging reverse logistics and sustainability performance research patterns have been ascertained over the decades. Such developing trends have transitioned from (i) an emphasis on reverse logistics and one or two sustainability performance dimensions to (ii) a focus on reverse logistics and the TBL of sustainability performance. Additionally, the empirical focus on reverse logistics and TBL in industrial (electronic manufacturing) sectors across emerging nations should be prioritised for value-added and extensive discussions. Recent interest in reverse logistics and sustainability research has led to the assessment of reverse logistics' effect on different sustainability performance elements and the development of a reverse logistics and sustainability performance network by determining the top 10 references with the strongest citation bursts lasting over five years (2009–2022).

In addition, the findings of this study contribute to practical relevance. It provides a comprehensive perspective on reverse logistics and sustainability performance for practitioners and economic society. The results of this study can be used by practitioners for selecting the best institutions to consult on reverse logistics and sustainability performance or to cooperate with. Moreover, the emerging trend in this domain may contribute to practitioners or society developing reverse logistics and sustainability performance. By and large, this research provides significant insights for practitioners or society to consider the economic, environmental, and social aspects of the triple bottom line approach to evaluate the performance of a reverse logistics network rather than focus on one or two sustainability performance dimensions. Lastly, this research highlights the importance of reverse logistics to support sustainable development in the manufacturing industry of developing countries. To date, little attention has been paid to assessing reverse logistics networks in developing countries from a triple-bottom-line perspective, including economic, environmental, and social factors. Therefore, this article presents possible avenues for the manufacturing industry in developing countries to develop sustainable reverse logistics networks in the future.

4.2. Limitations and Future Research

Several limitations can be found in our papers, including study scope, publication types, method, and search phrasing. Firstly, Scopus is used as the source of bibliometric data. Thus, future works should be performed in the following areas to expand the study's breadth and scope. Potential scholars could derive data from other databases (Web of Science) for comprehensive scientific data that are rigorously vetted and selected. Secondly, more English and non-English language papers associated with reverse logistics and sustainability performance could be evaluated. The findings could be compared against those of this study. Thirdly, multiple knowledge domain visualisation methods could be integrated for a holistic domain visualisation map of reverse logistics and sustainability performance. For example, UCINET could be incorporated to examine the multitude of collaboration network characteristics, such as the average path between two nodes, clustering coefficients, and degree of distribution. Lastly, the search keywords used in this study were suggested by some authors. However, many articles may lack the search term but focus on reverse logistics and sustainability performance. In addition, considering the intricacy of reverse logistics for sustainability, expanding the research based on a larger range of keywords would be necessary. Thus, covering a wider range of search terms would be a positive step forward in the study of the body of research around reverse logistics for sustainability.

Despite its limitations, the systematic and comprehensive review of reverse logistics for sustainability performance provides valuable insights and guidance to readers, including researchers and practitioners. Firstly, the notable literature gaps need to be bridged despite the integrative and critical nature of the studies in this domain. Several pertinent topics, such as game theory, artificial intelligence, and Industry 4.0, were proposed for further research based on the study outcomes. These topics characterised the emerging patterns ascertained through co-citation cluster analyses. Secondly, the study methodology level involving sampling questionnaires and cross-sectional surveys would complement the continuous optimisation of empirical approaches, such as game theory.

Thirdly, although the emergence and increasing use of specific Industry 4.0 technologies offer unique opportunities for enhanced system connectivity and intelligence [71], future research should determine the extent to which incorporating Industry 4.0 technology into reverse logistics enhances and impacts sustainability performance. In addition, it can also provide a potential competitive advantage for firms using emerging technologies, such as Industry 4.0 and artificial intelligence, that may improve reverse logistics to develop sustainable performance.

Lastly, this study found an inconsistent relationship between reverse logistics and sustainability performance. A considerable amount of previous research has focused on the advantages of reverse logistics on sustainability performance. For example, a well-managed reverse logistics project could achieve sustainability and generate a competitive advantage in terms of economic development [18,66,72], environmental protection [72,73], and social well-being [8,69]. Nevertheless, a disadvantageous relationship exists between reverse logistics and sustainability performance [23,74–76]. The positive and negative implications of reverse logistics on sustainability performance have been proven in multiple ways. This research categorised the relevant literature in this field (see Table 11). In respect to economic performance, it suggests that firms should utilise resources and raw materials as efficiently as possible to reduce costs and reap maximum profits [77]. Reverse logistics could significantly improve economic performance through cost savings [18] and higher revenue from sales of reclaimed and redeveloped products [8,78]. However, the study of Shaharudin et al. [79] showed that some of these elements proved contradictory given the absence of substantial economic benefits. Some studies showed the positive effects of reverse logistics on environmental performance, including reduced air, water, solid waste, less significant use of dangerous, hazardous, and poisonous items, and a number of environmental issues [48,66]. Environmental performance indicates that companies minimise environmental damage by cutting back on pollution, recycling and reusing waste goods, and reducing excessive resource usage [80]. Nevertheless, Mitra and Datta [74] and Abdullah and Yaakub [81] emphasised that manufacturing organisations do not hold a significant role incorporate reverse logistics operations in the design stage. At the same time, their studies recorded an adverse effect of logistics operations on environmental performance. Social performance denotes that organisations should incorporate social objectives into operations to guarantee work safety and conditions, health awareness, or the right to establish unions [82]. The social performance measurement employed the activities of organisations related to stakeholders' well-being and security, participation, equal treatment, and fulfilment [83]. Furthermore, reverse logistics play an important role in social performance [45,66,84]. To illustrate, by repairing or restoring broken-down products, reverse logistics could boost customers' happiness and loyalty [6]. However, the reverse logistics-social performance link was discovered with contradictions by other empirical works from a social perspective [23,85].

This inconsistency rendered the reverse logistics impacts on sustainability performance inconclusive. As a result, a moderator was proposed to optimise the reverse logistics-sustainability performance link. Future works should identify empirical proof of the factors influencing the reverse logistics-sustainability performance connection. In line with the study content, potential researchers could transition from correlation-oriented explorations to those of causality.

Table 11. The relationship analysis of research fields.

Research Fields	Reference	Sustainability Performance Dimension		
		Environmental Performance	Economic Performance	Social Performance
The positive relationship between reverse logistics and sustainability performance	Sarkis et al. [8]	√	√	√
	Javed et al. [67]	√	√	√
	Hasegawa et al. [73]		√	
	Sharma et al. [78]		√	
	Govindan et al. [45]	√	√	√
	Turrisi et al. [86]		√	
	Younis et al. [75]			√
	Huang et al. [72]	√	√	
	Nikolaou et al. [87]	√	√	√
	Ye et al. [18]	√		√
	Pourmehdi et al. [69]	√	√	√
	Rahimi and Ghezavati [84]	√	√	√
	de Oliveira et al. [66]	√	√	
The negative relationship between reverse logistics and sustainability performance	Mitra and Datta [74]	√		
	Abdullah and Yaakub [81]	√		
	Laosirihongthong et al. [85]			√
	Geng et al. [23]			√
	Shaharudin et al. [79]		√	
	Rasit et al. [76]	√	√	√
No relationship between reverse logistics and sustainability performance	Schoenherr et al. [88]		√	
	Younis et al. [75]	√		
	Rasit et al. [76]	√	√	√

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