Two Decades of Closed-loop Supply Chain: A Bibliometric Analysis

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Abstract

Supply chain management has evolved from local and regional purchasing and supply activities prior to the industrial revolution, to the current form of technology-led, data-driven, collaborative, and global supply network. Adoption of contracts among the channel members enables optimization, coordination, and decision-making. Through literature reviews based on sourcing, production, logistics, and others areas within supply chain are rich in their respective areas, systematic analyses of closed-loop supply chain (CLSC) are lacking. We examine studies on CLSC to discover the knowledge and direction of researches through systematic bibliometric analysis. We adopt citation, co-citation, and co-occurrence of closed-loop supply chain research articles from 2001 to 2021 using data obtained from the SCOPUS database to identify and validate the themes and sub-themes in this research area.

Keywords
Closed-loop supply chain, Contracts, Bibliometric analysis, and Network analysis

1. Introduction
Recently, there is an increasing concern regarding environmental pollutions such as electronic waste (e-waste). In this regard, many countries have considered various measures for intensifying legislative efforts such as Extended Producers Responsibilities (EPR) regarding the protection of the environment and resources (Hammond and Beullens, 2007). These initiatives lead to the adoption of practices like collection and remanufacturing of used items (Paksoy et al., Özceylan, 2011; Kuo, 2011) directly by companies or indirectly through partnerships around the world.

Electronics giants such as Samsung, Brother, Apple, Hewlett-Packard, and Kodak have collection programs for used products. These programs promote social prestige of the organizations and also benefits them through manufacturing cost reduction (Guide et al., 2003; Zhang and Ren, 2016). The collection and remanufacturing of used products (closed-loop supply chain (CLSC)) reduces both the raw material requirement and the amount of waste produced and contributes to the development of economy and the environment. Companies like Croma, Apple, Panasonic, and LG adopt incentive schemes for consumers to exchange the old devices. Through such initiatives they create awareness on e-waste and help in reducing hazardous waste flowing into the earth from e-waste dumping. Apple currently uses 100% recycled rare earth and tin in its new iPhones and iPads, LG engages only with recycling companies that do not incinerate, contribute to landfill, or export hazardous waste to developing countries and runs an 'Exchange and Take back' program, Panasonic and Chinese phone maker Xiaomi engage the youth for creating awareness on environmental issues related to e-waste.

Companies like Kodak, HP, and Canon focus on reverse logistics to obtain used products from customers, which helps in generating more profits (Savaskan and Van Wassenhove, 2006). There are various ways of returning/collecting used items from the end customers in CLSC are studied in literature. These are manufacturer direct collection, the retailer or a third-party collection, and dual-channel where both the manufacturer and retailer/third party or a retailer and third-party collection, etc. In this regard, contract mechanisms such as revenue-sharing, wholesale price, two-part tariff, reward-penalty, etc. have been developed and studied to collect and recycle the end-of-use and the end-of-life products for different situations (Wang et al., 2018; Taleizadeh et al., 2018). Studies have shown that adoption of such contracts in CLSC can help achieve higher overall supply chain profit (Chang and Zhang, 2008; Bellantuono and Pontrandolfo, 2011; Paksoy et al., 2011; Zunya et al., 2016; Feng et al., 2017; Zou et al., 2018; Kim et al., 2020; Hosseini-Motlagh et al., 2020; Liu et al., 2021).

This study aims to systematize the scientific knowledge of research on CLSC adopting contract mechanism by the academic community. Literature systematization helps in identifying and developing new research enquiries and advancing the field of study (Gaziulusoy and Boyle, 2013). In this study, we have adopted scientometric form of bibliometric analysis.

The remainder of the paper is organized as follows. The methodology used in this study is provided in Section 2. The results, analysis and inferences are provided in Section 3. Section 4 presents the discussion and the inferences that emerge from synthesis of different analyses. The last section concludes this paper with the limitations of this study and future research directions.

2. Methodology

2.1 Analytical procedure

We employ bibliometric analysis and econometric analysis to complement and validate our study results. We first conduct bibliometric analysis of the selected documents. Bibliometrics is a process used to analyse the development and trends of research areas employing different mathematical and statistical methods on the existing literature (Yu et al., 2017). We use specific bibliometric techniques to analyse the studies on closed-loop supply chain: i) citation, ii) co-citation, iii) and co-occurrence analysis. Citation analysis provides ranking and clusters of cited authors or journals by evaluating the citation frequency in terms of their significance (Garfield, 1972). Co-citation analysis is used to identify the relationship between existing studies in terms of authors, journals or references forming an undirected network (Small, 1973). A co-citation occurs when a third study cites two studies together. Co-occurrence or co-word analysis clusters common keywords between the documents to identify the dynamics or intellectual core of the research area (Chen, 2006).

Different software applications and languages are available for bibliometric analysis, such as VOSviewer (van Eck & Waltman, 2010), BibExcel (Persson et al., 2009), Gephi (Bastian et al., 2009), CitNetExplorer (van Eck & Waltman, 2014), Biblioshiny (Aria & Cuccurullo, 2017), NodeXL (Smith et al., 2010) and others. All software packages have different capabilities and limitations, so we chose VOSviewer. In this study, we have used VOSViewer and Biblioshiny for performing various analysis and data formatting. VOSviewer has the capability to handle different databases like Web of Science, Scopus, Dimensions, and PubMed and provides network maps with distinct clusters, easy to understand and interpret.

2.2 Comprehensive review: Data collection and screening

We considered all the different combination of keywords and examined the results that each respective search has provided. We found that the used phrases yield relevant studies that help us form a good corpus. We have also allowed the inclusion of conference proceedings in the corpus. Many recent studies and research are usually presented in the conferences and it is appropriate to include the conference proceedings as they provide useful and emerging research ideas. We have used SCOPUS database as the source of citation database (https://www.scopus.com/search/form.uri?display=basic#basic). SCOPUS is a database composed of records across disciplines covering over 75 million records and almost 25 thousand titles. The data from SCOPUS database for the keywords search up to 2021 was retrieved. The search generated 227 articles, comprising 5948 references from 108 sources.

Using SCOPUS database, we considered 5 different combinations of keywords to extract research articles and conference proceedings for analysis. Book chapters and review articles were excluded from the corpus as these contribute very less to the current trends in research. The search was limited to “Business, Management and Accounting”.

A systematic analysis of the retrieved papers was done to determine the relevance for the study. After downloading the data, the files were reviewed to delete duplicate files from the corpus using Microsoft Excel. Each article that remained after deleting the duplicate files were read and reviewed individually for consideration for including in the corpus for further analysis. The indication that supply chain contracts are used in the paper from the title, abstract, and/or keyword was used as the inclusion criteria for retaining the papers in the corpus for bibliometric analysis. The sequence of data collection and retention for bibliometric analysis is summarized below.

- Step 1: Use different keywords to search for articles in SCOPUS database
- Step 2: Remove duplicate files from the corpus
- Step 3: Read and analysis and the papers to remove the papers that do not meet the inclusion criteria for bibliometric analysis. The papers that described the use of contract in closed-loop supply chain in the abstract, title and/or keywords were retained for the analysis.

The different keywords used for data retrieval and the document count for each keyword with the number of documents retained after each process is provided in Table 1.

Table 1. Keywords used for data retrieval

1st step: Retrieve papers using keywords from SCOPUS database		
Sl. No	**Keywords used**	**Articles retrieved**
1	Supply chain AND contract AND closed-loop	210
2	Supply chain AND contract AND reverse logistics	32
3	Supply chain AND contract AND end-of-life	22
4	Supply chain AND contract AND circular economy	15
5	Supply chain AND contract AND reverse channel	17
Total papers retrieved		296
2nd step: Remove duplicate files		
1	Number of papers after removing duplicate files	259
3rd step: Remove papers that do not focus on closed-loop contract mechanism		
1	Number of papers finalized for bibliometric analysis	229

3. Results and Discussion

3.1 Descriptive analysis

Table 2. Summary of Descriptive Analysis

Description	**Results**
Timespan	2001:2021
Sources	108
Documents	227
Average years from publication	5.23
Average citations per document	16.84
Average citations per year per document	3.375
Total references	5948
Authors	460
Countries	30

The corpus retrieved from SCOPUS database consisted of documents from December, 2001 to August, 2021, a span of 20 years. The corpus for bibliometric analysis on closed-loop supply chain with contract mechanism consists of 227 documents from 108 sources with 5948 references. A total of 4601authors from 30 countries contributed to the studies.

3.2 Bibliometric analysis of Trend of publication year-wise

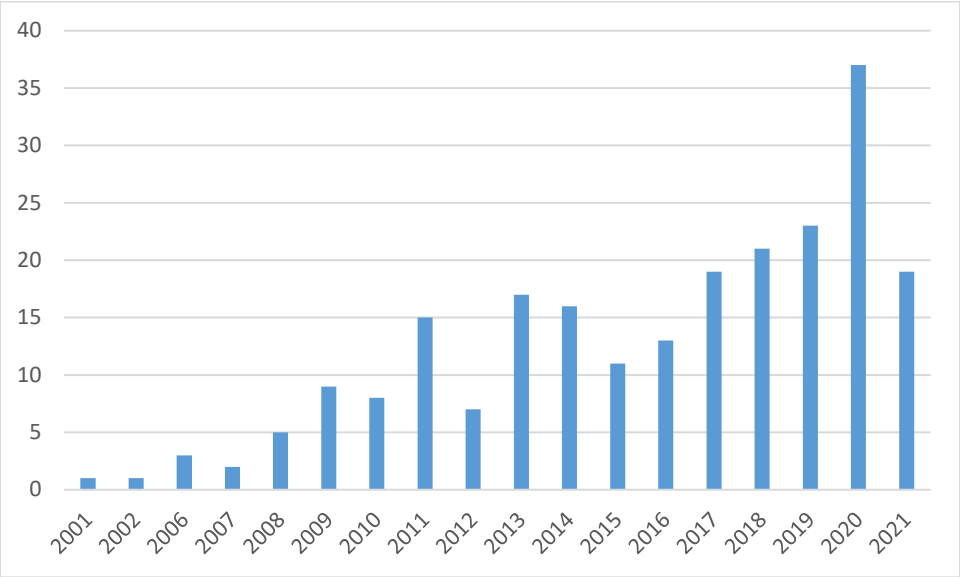

Figure 1. Number of publications per year on closed-loop supply chain with contract mechanism

From Table 2 we see that there are 229 articles found on closed-loop supply chain with contract in SCOPUS. An analysis of these articles on year wise trend of publication is provided in Figure 1. It is observed that 198 out of 227 articles were published in the years 2011–2021. The figure shows an increasing trend from early 2000s to 2020 which can indicate an increase in the number of researches on the topic each year by researchers showing its interest among the research community. The highest publications are in 2020, and a lower number of publications in 2021 can be because of the reason that the data has been collected only for half a year in 2021.

3.3 Bibliometric analysis of top journals

Table 3. 10 top journals for closed-loop supply chain with contract based on number of citations

Source	Number of citations	Number of articles
International Journal of Production Economics	924	10
European Journal of Operational Research	423	6
Journal of Cleaner Production	410	20
International Journal of Production Research	235	8
Sustainability (Switzerland)	168	15
Manufacturing and Service Operations Management	164	1
Annals of Operations Research	154	5
Production and Operations Management	124	1
Transportation Research Part D: Transport and Environment	123	1
Computer Integrated Manufacturing Systems	73	11

A detailed citation analysis was generated using the data from SCOPUS and the resulting data is analysed. A citation analysis provides ranking and clusters of authors or journals referenced by other researchers in their work and evaluates the citation frequency in terms of their significance. An author or journal is said to be more important when it has higher number of citations when compared to other authors or journals. The 227 papers considered in this study received a total of 3545 citations based on source and were published in 63 journals. Table 3 lists the top 10 cited

journals based on citation analysis. The top 5 journals contribute to 61% of total citations. The top 5 contributing journals are: *International Journal of Production Economics* (26.06%), *European Journal of Operational Research* (11.93%), *Journal of Cleaner Production* (11.56%), *International Journal of Production Research* (6.6%), and *Sustainability* (4.74%)

3.4 Bibliometric analysis of Top authors

Table 4. 10 top authors for closed-loop supply chain with contract based on number of citations

Author	Number of citations	Number of articles	Average citations per article
Govindan K.	452	4	113
Xu L.	414	3	138
Choi T.-M.	362	4	90.5
Li Y.	348	6	58
Xie J.	216	4	54
Wang W.	207	4	51.75
Cárdenas-Barrón	191	2	95.5
Modak N.M.	191	2	95.5
Liang L.	182	3	60.67
Hong X.	176	4	44

Table 4 displays the top 10 authors who contributed to studies of closed-loop supply chain with contract. The 227 papers considered in this study received a total of 10793 citations based on authorship and were authored by 332 authors. We observe from the table that Govindan K. received the highest citations followed by Xu L. The top 10 authors received 25% of the citations while the top 72 authors contributed to 75% of the citations. This shows that studies are widely distributed among many researchers. Hosseini-Motlagh S.M. published the highest articles (8 papers) followed by Li Y. (6 papers).

3.5 Bibliometric analysis of Most cited articles

Table 5. 10 top cited articles for closed-loop supply chain with contract

Title	Authors	Journal name	Publication year	Total citations
Channel Leadership, Performance and Coordination in Closed Loop Supply Chains	Choi T.-M.	International Journal of Production Economics	2013	263
Reverse Supply Chain Coordination by Revenue Sharing Contract: A Case for the Personal Computers Industry	Govindan K.	European Journal of Operational Research	2014	175
Supply Chain Coordination for False Failure Returns	Ferguson M.	Manufacturing and Service Operations Management	2006	164
Coordinating a Socially Responsible Closed-Loop Supply Chain with Product Recycling	Panda S.	International Journal of Production Economics	2017	145
Joint Advertising, Pricing and Collection Decisions in a Closed-Loop Supply Chain	Hong X.	International Journal of Production Economics	2015	143
Sharing Responsibility for Product Recovery Across the Supply Chain	Jacobs B.W.	Production and Operations Management	2012	124
Reverse and Closed Loop Supply Chain Coordination by Considering Government Role	Heydari J.	Transportation Research Part D: Transport and Environment	2017	123
Strategic Planning: Design and Coordination for Dual-Recycling Channel Reverse Supply Chain Considering Consumer Behavior	Feng L.	European Journal of Operational Research	2017	121
Coordination Contracts of Dual-Channel with Cooperation Advertising in Closed-Loop Supply Chains	Xie J.	International Journal of Production Economics	2017	119
Acquisition Pricing and Remanufacturing Decisions in a Closed-Loop Supply Chain	He Y.	International Journal of Production Economics	2015	89

Table 5 displays the top 10 articles on closed-loop supply chain with contract. The 227 papers considered in this study received a total of 3413 citations. "*Channel Leadership, Performance and Coordination in Closed Loop Supply Chains*" by Choi T.M published in *International Journal of Production Economics* is the most cited paper with a total of 263 citations. The top 10 authors received 42.95% of the citations while the top 14 authors contributed to 51.68% of the citations. This shows that studies on closed-loop supply chain with contract are concentrated among few articles by few authors.

3.6 Bibliometric analysis of author co-citation analysis

Further analysis of the data was carried out on the 227 papers under review. A co-citation analysis based on authorship was carried out and the resulting network map is provided in Figure 2. It can be observed from the figure that there are four clusters of authors cited together by other researchers. A comparison of data from top cited authors (Table 4) and author co-citation analysis (Figure 2) shows that majority of the highest cited authors who contribute to closed-loop supply chain with contract is the same in both the analyses.

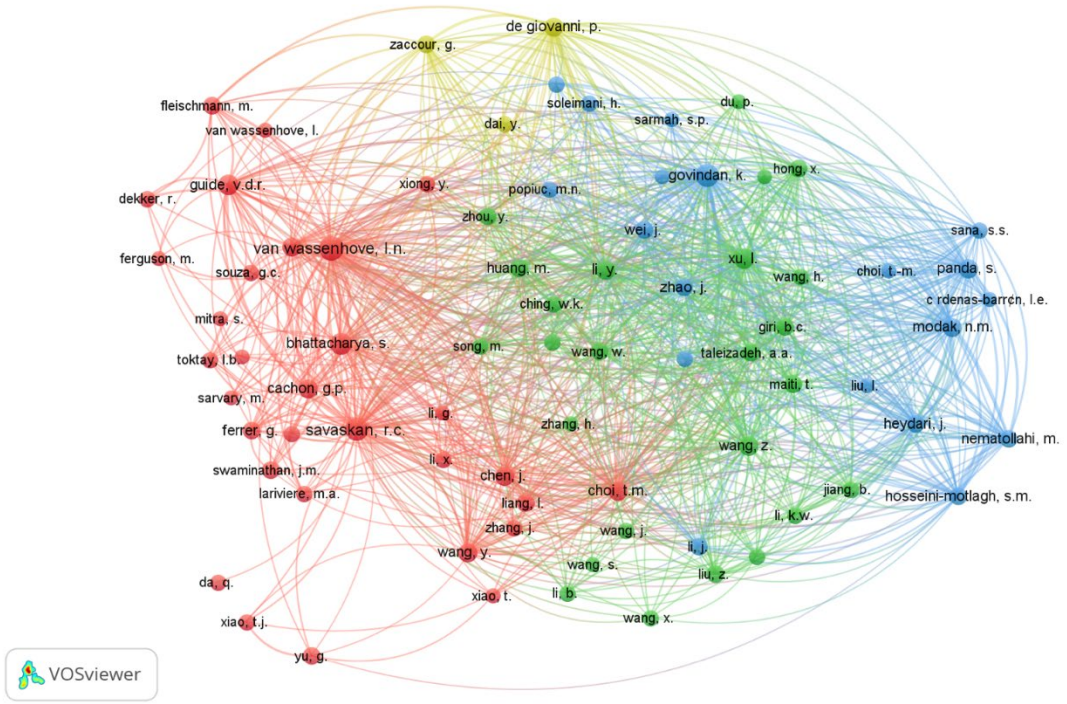

Figure 2. Network map of author co-citation analysis

3.7 Bibliometric analysis of journal co-citation analysis

Another analysis of the data was carried out on the 227 papers under review based on the source. The resulting network map of the journal co-citation analysis is provided in Figure 3. Analysis shows that there are 1478 journals co-cited by different papers. It can be observed from the figure that there are five clusters of journals cited together by other researchers. A comparison of data from top cited journals (Table 3) and journal co-citation analysis (Figure 5) shows that majority of the highest cited journals that contribute to closed-loop supply chain with contract is the same in both the analyses. *International Journal of Production Economics* received the highest citation (810) followed by *European Journal of Operational Research* (624).

3.8 Bibliometric analysis of Top countries

Figure 4 depicts a TreeMap of the countries with highest number of citations on closed-loop supply chain with contract. Figure shows that papers from China has the highest citation of 2002 followed by United States with 776 citations. A simple calculation shows that China, United States, and Denmark received 55.44% of the citations from

a total of 5826 citations. The top 10 countries received a total of 86.59% of the citations. This observation denotes that the focus on closed-loop supply chain with contract studies is concentrated in only few countries.

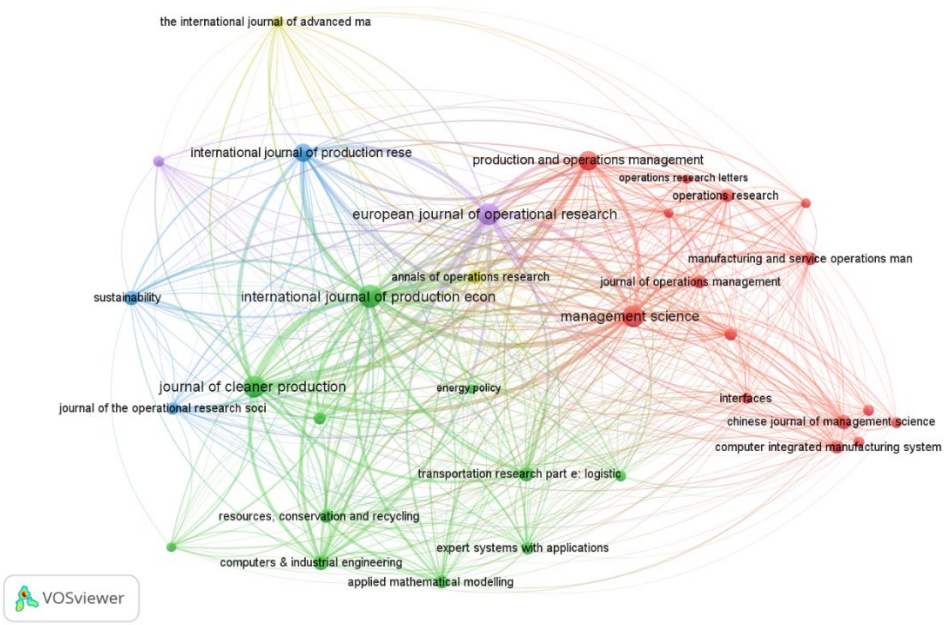

Figure 3. Network map of journal co-citation analysis

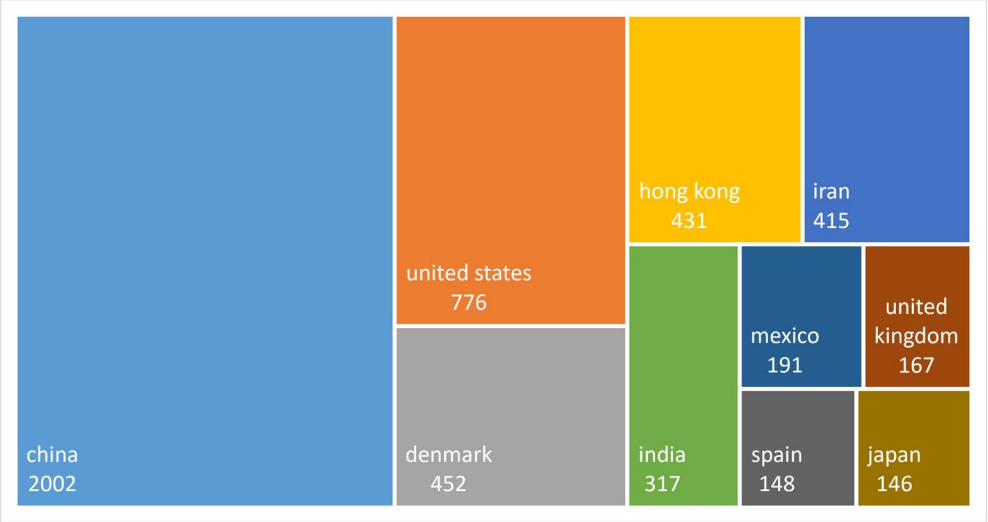

Figure 4. TreeMap of 10 countries with highest number of citations on closed-loop supply chain with contract

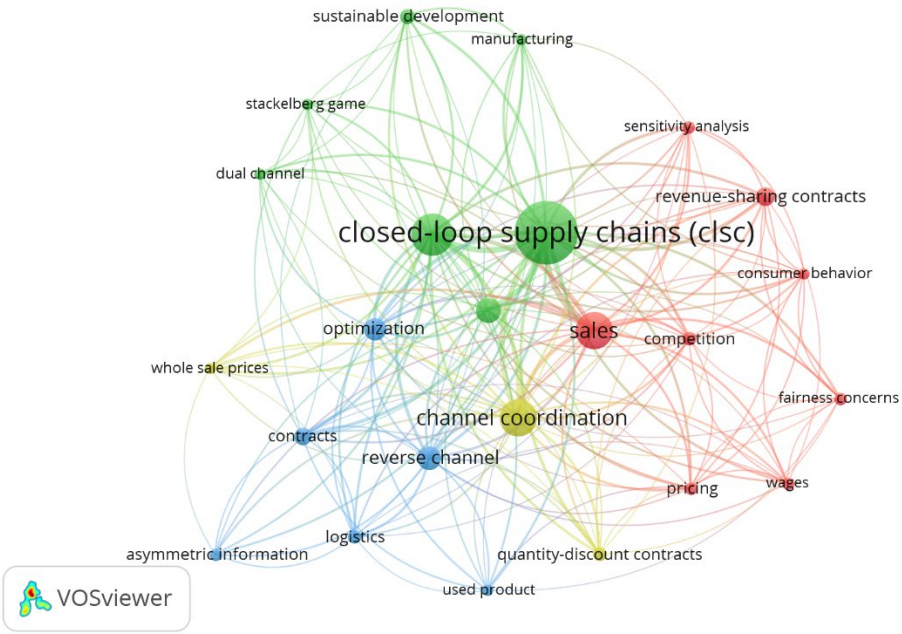

Figure 5. Network map of keyword co-occurrence analysis

3.9 Bibliometric analysis of Keyword analysis

Further analysis was carried out on the corpus to obtain insights on the different themes that are studied by different researchers. VOSviewer (Version 1.1.15) was used to obtain the keyword map consisting of different clusters of keywords (Figure 5). A minimum of 9 occurrences of the keywords was used which resulted in 24 relevant keywords. These 25 words were automatically classified into four clusters by the software. Some of the words that are most repeated in each cluster were:

- Cluster 1: Sales, competition, pricing
- Cluster 2: Remanufactured products, closed-loop supply chains (CLSC), sustainable development, supply chain
- Cluster 3: Reverse channel, optimization, used product
- Cluster 4: Quantity-discount contracts, channel coordination, whole-sale prices

From the most occurring words we can summarize that cluster 1 mostly focuses on optimal pricing, cluster 2 on sustainability, cluster 3 on reverse channel optimization, and cluster 4 on different contracts.

4. Conclusion and Future Research

Recently, there is an increasing concern regarding environmental pollutions such as electronic waste. Many researchers have been focusing on the adoption of contract mechanisms among the channel members to reduce e-waste and to optimize the profitability of the supply chain members. Due to the increasing concern for environmental degradation and focus on reducing the sources, many studies are carried out. In this regard, this study considers a bibliometric analysis approach to quantitatively analyze the literature on closed-loop supply chain with contracts. This study aims to identify the extend and the areas of study. The data for this study was extracted from SCOPUS database, and the first study was found to be published in December of 2001 making the corpus consisting of two decades of research. All the tables and figures are obtained by analysing the corpus in VOSviewer. Different analyses carried out in this study indicate that most of the work are concentrated or limited to few researchers, countries, and journals indicating that there is scope for further studies. From the co-occurrence analysis, we can summarize the themes that have been studied as price optimization, environmental sustainability, reverse channel optimization, and adoption of contracts.

We feel that the study was subject to some limitations, and they can be addressed in future studies. First, in this study we used data obtained from SCOPUS database. In future research, it will be useful to add more keywords and do the analysis in the corpus obtained and/or use data from other database like Web of Science. Second, we used different combinations of keywords to identify and extract data for analysis. This search is based on our review of the literature and our understanding of the area. However, this set of keywords can be different as well. If different keywords are used, it may result in a corpus that is different from what we obtained. Third, this study employed only citation, co-citation, and co-occurrence analyses. Other methods such as factor analysis, cluster analysis and principle-component analysis can be used to identify and complement the findings. Fifth, apart from the analysis we have performed, thematic analysis can be used to classify and understand the themes of research. It will be useful to employ thematic analysis to cross-validate the themes we identified through co-occurrence analysis.

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