Supply Chain Resilience – A Bibliometric and Content Analysis

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ABSTRACT

The threat of disruption is higher than ever making it critical for businesses to build resilient supply chains and implement risk management strategies that embrace complexity for accelerating performance. With a substantial improvement in the frequency of academic publications, there has been witnessed an exponential growth in the ever-growing and immensely important area of supply chain. Publications in the field concentrate on a few key areas of supply chain flexibility, namely supplier selection and assessment, agile and responsive logistics. This paper constitutes of a Bibliometric investigation that lays out a base for further examination of the subject. The examination starts by recognizing more than 2500 journals relevant to the field of Supply chain risks, disruptions and vulnerabilities, which are further funnelled down for the purpose of Bibliometric analysis and demonstrates various key findings. Utilizing instruments for Bibliometric analysis key findings were explored for the key themes and collaborative designs. Further, the development in the relevant and interested domain with respect to time and distinguishing research engrossments as well as possible areas regarding to the upcoming exploration are discussed. These discussions could guide further examinations of this field.

Introduction

Over the last few years, course books, article and advisory reports in supply chain management (SCM) emphasized on concepts of low stocks, single sourcing, JIT delivery & centralization. Noticing these recommendations, numerous organizations attempted viably executing this 'lean' approach and figured out how to accomplish these efficiency gains. Over a similar period, they have globalized all sourcing activities, manufacturing and various other activities, resulting in knotty networks of mutuality between manufacturing plants, distribution centres, cargo terminals and stores globally. This, empowered organizations to expand their market regions, outsource their creation to cheap cost nations and enhance respective supply chain bases.

Noticeably after implementing this, the organizations have also expanded the risks of exposures to various kinds on vulnerabilities impacting their supply chains. They have constantly chosen maximum productivity with increased hazard. Lee (2004) describes this as one of the 'perils of efficiency'. A fixed proportion in the stock that used to provide a hedge against inward and exterior vulnerabilities has definitely shrunk Organizations started relying & setting more noteworthy dependence on fewer suppliers, transporters and transport hubs and regularly lessening adaptability with which they can change and reschedule at brief notification. In the last few decades, frequency & power of catastrophic events were observed as expanding, worldwide markets have gotten fiercer and threats from terrorism, have multiplied.

Organizations modified their supply chains to be more sensitive to outer shocks when the dangers of such stuns expand. The result is a flood in the amount of disappointments. Best case scenario, these disappointments have resulted in transitory, limited disturbance. Given the size of the subsequent interruption, public governments and worldwide association have normally started to take a nearby enthusiasm for the issue, investigating the approaches that should be possible to limit the danger of a supply chain coming up short as well as amplify the pace with which it has the ability to recuperate as soon as a debacle occurs, what is currently named 'supply chain resilience'. Sheffi (2005) defines resilience as the "ability to bounce back from large-scale disruptions". Any resilient organisation may also be able to reduce the depth and width of the disruption & eventually the resources required to 'bounce back'. This is reflected in definitions of resilience from, respectively the OECD (Duval and Vogel, 2007) and World Economic Forum

(2012): 'the ability to maintain output close to potential in the aftermath of shocks. 'the ability of a global supply chain to reorganize and deliver its core function continually, despite the impact of external and/or internal shocks to the system'.

Analysis of Network based on Bibliometric instruments can be demonstrated as ground-breaking for recognizing set up and developing effective areas. Likewise, it may be helpful in distinguishing the groups of research as well as researchers demonstrating how the different zones of ideas may have developed dependent on authors and institutional standards. This paper puts ahead an exhaustive assessment relevant to the domain, initiating by considering a cluster of more than 2500 published articles and separating the selected bunch to further powerful investigations.

Research Methodology

Bibliometric and content analysis was used for this study. A Bibliometric analysis comprises of applying factual strategies to decide subjective and quantitative changes in a given logical exploration topic, set up the outline of publications as per the theme, as well as recognize inclinations inherent in a certain domain. Moreover, this kind of investigation churns out helpful data to authors trying to assess scientific advancements in light of the fact that a Bibliometric examination goes about as a guide for the status of research into SC resilience.

Bibliometric studies include investigative methods like citation and co-citation analysis. Citation examination is a method of estimating the relative significance or effect of a researcher, an article or a publication by tallying the occasions that writer, article, or distribution has been referred to by different works. This kind of analysis may be done for various purposes such as to set up the effect that a specific work has had by recognizing which different creators put together their work with respect to it or referred to it inside their own papers. To get familiar with a field or a subject by recognizing fundamental works here or for advancement and tenure reasons by taking a look at the nature of sources where a researcher's work has been distributed and referred to. Co-reference investigation includes following sets of papers that are cited together in the source articles. At the point when similar sets of papers are co-referred

to by numerous creators, groups of research start to shape. The co-cited papers in these bunches will in general offer some basic subject. Joined with single-interface bunching and multidimensional scaling strategies, co-citation investigation can truly plan the structure of particular exploration areas.

We utilized Scopus database in order to gain insights for Bibliometric study. It is broadly accepted and regularly used analyses. Scopus, Elsevier's theoretical and information base dispatched in the year 2004. Scopus shelters almost 36,300 titles from around 11,677 publishers, of which almost 34,300 are peer-inspected journals in the domains such as: wellbeing sciences, sociologies, life sciences and physical sciences. This examination utilizes the Scopus online information base, which houses logical archives over all controls. The way that the Scopus gives information on logical examination yield empowers the Bibliometric investigation on the grounds that the Scopus offers information on output, dissemination, coordinated effort, and impact.

2.1. Defining the appropriate search terms: -

Keywords utilized in order to collect information includes, "Supply Chain", "Resilience", "Risk", "Disruption" and "Vulnerability". We took utmost care to include all the outlooks of keywords chosen. Four blends of these catchphrases were utilized as shown in Table 1.

Table 1: Keyword Search

Search Keywords
1. supply AND chain AND resilien*
i.   OR
2. supply AND chain AND risk*
ii.   OR
3. supply AND chain AND vulnerab*
iii.   OR
4. supply AND chain AND disruption

2.2. Alteration of the search results

Out of 2871 papers, a handful of papers appear in multiple categories and multiple languages. So, we eliminated these duplications & limited the language to English. Additionally, there were

some non-refereed papers as well as few which were published in a commercial magazine and cannot be considered as scientific contributions. Thus, eliminating such articles helped in funnelling down the number. Limiting the area of study to Business, Decision Sciences & Economics as well as considering the articles for the last 15 years viz. (2006-2020), we gain around 984 papers. For the further analysis, a bibtex file of these articles were used which was analysed using R- Biblioshiny package.

Fig. 1 Approach taken for the Bibliometric study

Current Status

3.1   Publishing Trend:

We noticed and took into consideration the quantity of articles which were published in journals for a span of 15 years (2006-2020). As compared to the current frequency of publication, it is clearly visible that in the year 2006, the frequency of publication was quite less. Over the decade, the interest in this topic grew exponentially with a growth rate of 18.78%. Year

2020 witnessed the greatest number of published articles which implies an ever-growing trend towards supply chain resilience.

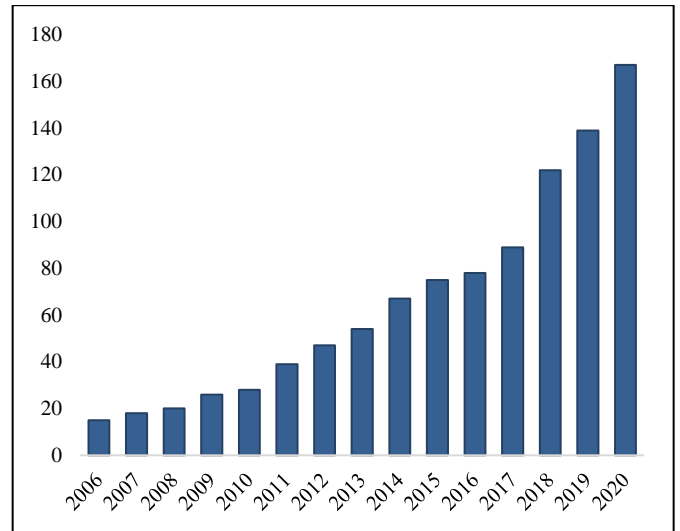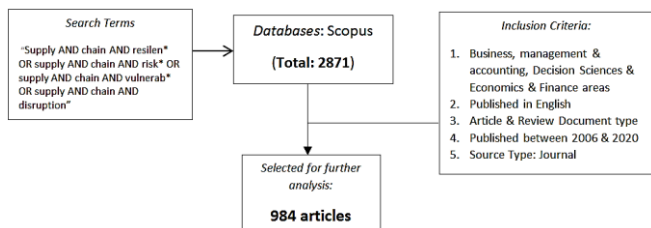**Fig. 2 Trend of Publication in the field of Supply Chain Resilience**

3.2   Documents by subject area in the field of supply chain resilience:

As shown in Fig. 3, ten types of the subject area amongst which all the 984 papers are being published. The results demonstrate that majority of 33.9% of the publications are in the area of "Business, Management & Accounting" followed by "Decision Sciences" at 24.8% with the least quantity of articles being published relevant to the field of "Agricultural & Biological Sciences" at 0.5%.

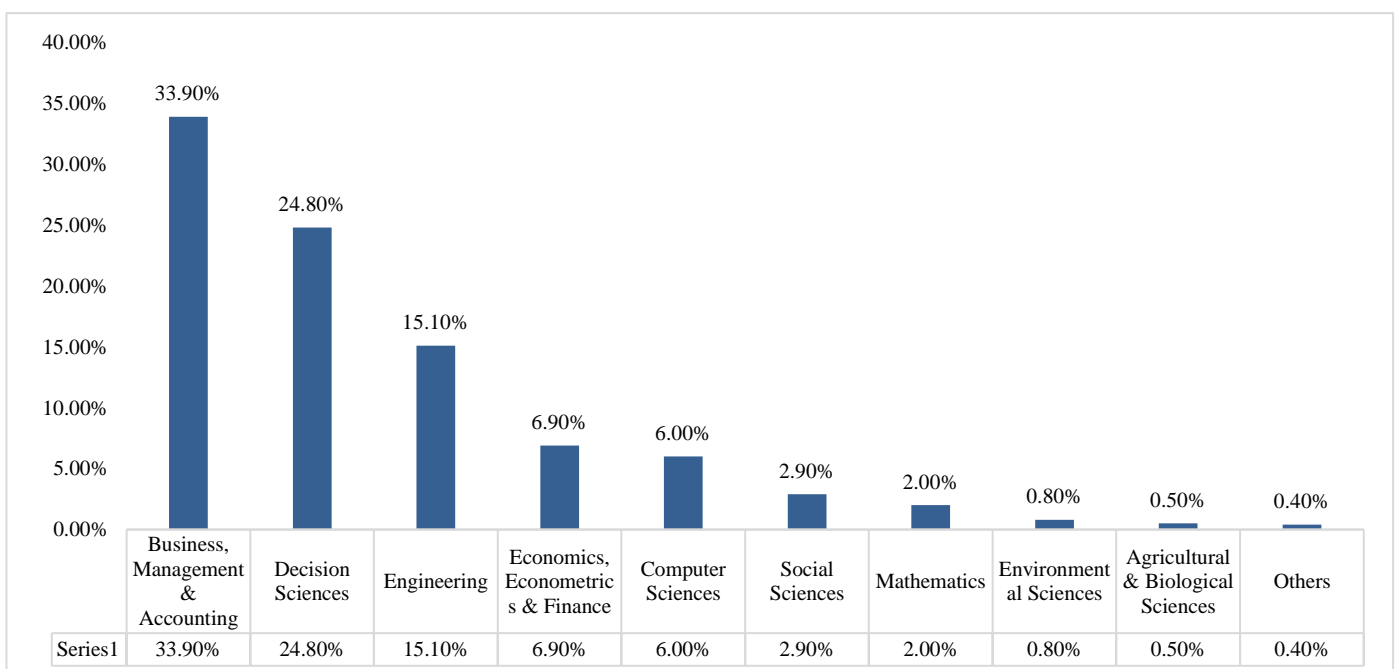|	Business, Management & Accounting	Decision Sciences	Engineering	Economics, Econometrics & Finance	Computer Sciences	Social Sciences	Mathematics	Environmental Sciences	Agricultural & Biological Sciences	Others
Series1	33.90%	24.80%	15.10%	6.90%	6.00%	2.90%	2.00%	0.80%	0.50%	0.40%

Fig. 3 Documents by subject area in the domain of supply chain resilience

3.3 Top 10 publishing journals

Table 2 depicts that out of all journals, top 10 journals have published a total sum of 399 articles, contributing around 41% of all the papers published. It also states the 10 journals in which these papers appeared and were published. At a count of 112 articles and percentage contribution of 28.07%, the "International Journal of Production Research" published the most articles which was then followed by "International Journal of Production Economics" at a count of 69 and contributing 17.29%.

Journals	Articles	%
International Journal of Production Research	112	28.07%
International Journal of Production Economics	69	17.29%
Supply Chain Management	40	10.03%
Annals of Operations Research	37	9.27%
Transportation Research Part E: Logistics and Transportation Review	35	8.77%
European Journal of Operational Research	24	6.02%
Omega (United Kingdom)	23	5.76%
International Journal of Logistics Management	21	5.26%
International Journal of Logistics Systems and Management	20	5.01%
International Journal of Supply Chain Management	18	4.51%

Table 2. Top 10 journals contributing to the domain of Supply Chain Resilience

3.4 Country-wise articles:

Figure 4 and Table 3 indicates the country-wise publications of articles from year 2006 to 2020. The table demonstrates that majority of the papers amongst top 10 countries are being published by USA with 648 articles, the second being China at 229 articles with the least country being Brazil at only 42 documents. Approximately 74% of articles are published by these top 10 countries.

Fig.4 Country Scientific Production

Table 3. Country wise Production

Region	No. of articles
USA	648
CHINA	229
UK	137
INDIA	125
IRAN	91
GERMANY	85
AUSTRALIA	80
CANADA	54
FRANCE	47
BRAZIL	42

Bibliometric Analysis

4.1 Authors Influence

Utilization of BibTex is done so as to extract the required information regarding the number of articles produced by an author. As shown, Table 4 consists of column of author was extricated from the BibTex document and recurrence of appearance of the authors was documented. The table frameworks top 10 researchers and the amount of papers that has been authored or co-authored by them. From the observations made, Ivanov D published the greatest number of articles (36) with a total citation of 1535 which was followed by Dolgui A by publishing 13 articles with total number of citations as 1060.

Table 4: Top 10 contributing authors with number of published articles and total citations

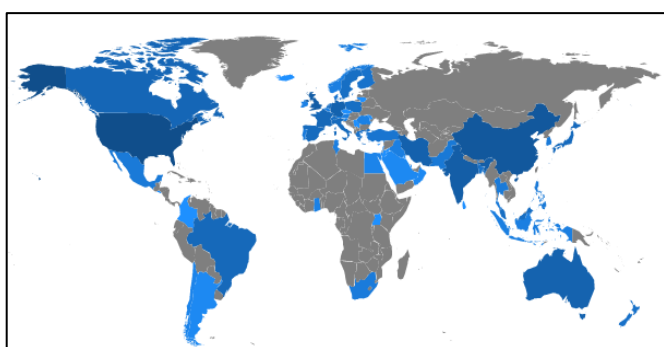| Name	No. of published articles	Total Citations
Ivanov d	36	1535
Dolgui a	19	1060

Sawik t	16	773
Wagner sm	12	927
Blackhurst j	11	1250
Paul sk	11	133
Sokolov b	11	898
Hosseini-motlagh sm	9	47
Shen zjm	9	428
Craighead cw	8	1003

Figure 5 shows clearly that a collaborative network can be isolated into a various category of groups with various hues dependent on participation quality. The dimensions of the box illustrate the number of times the occurrence of each researcher has occurred. The conjoined arrow between the boxes alludes to the cooperative connections amongst the primary researchers. It ought to be noticed that the core creator in a specific gathering may likewise have feeble communitarian associations with the individuals that were present in other clusters.

Fig.5 Collaborative network

4.2 Affiliation statistics and analysis

Table 5 illustrates top 10 organisations country-wise categorised by the frequency of the publications in the domain of SC resilience. The table represents that the studies relevant to the domain was managed globally, consisting of countries like Germany, USA, Iran, etc. The most productive, with 36 publications, was the Berlin School of Economics and Law in Germany, the second spot with 21 articles bagged by the Iran University of Science and Technology of Iran, University of Tehran published 20 articles, Auburn University published 19 articles, Michigan State University bagged the 5th position with around 17 articles, etc. Additionally, the top organisations with strong citations are shown in Figure 6, which indicates affiliations, cited sources and sources from left to right.
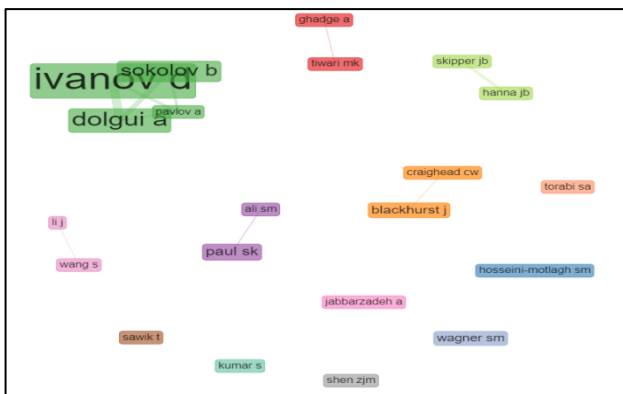
Table 5: Top 10 organisation with their countries and frequency of publications

Rank	Affiliations	Articles	Country
1	Berlin School of Economics and Law	36	Germany
2	Iran University of Science and Technology	21	Iran
3	University of Tehran	20	Iran
4	Auburn University	19	USA
5	Michigan State University	17	USA
6	Agh University of Science and Technology	15	Poland
7	University of Michigan	14	USA
8	Cranfield University	13	UK
9	Iowa State University	13	USA
10	Swiss Federal Institute of Technology Zurich	13	Switzerland
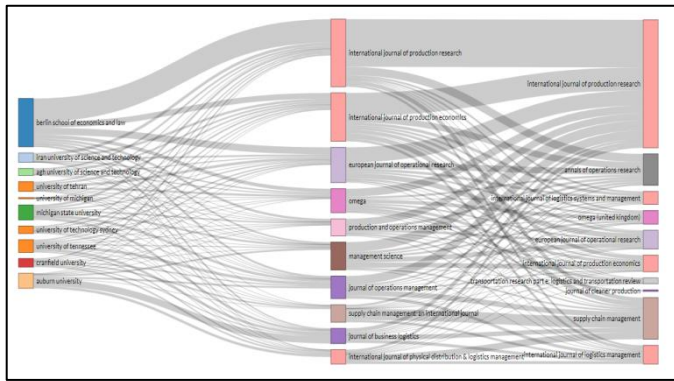
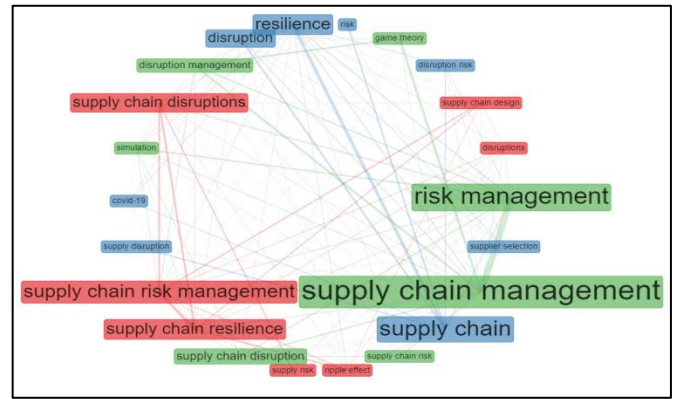**Fig. 6 Top institutions with strong citations**

4.3 Keyword Analysis

Figure 7 illustrates the cooccurrence network of keywords in the following automatic layout with normalization being set as association and clustering algorithm being used as Louvain. The top 50 keywords were being selected for this analysis which gave insights about the keywords in the field of SC resilience.

Fig. 7 Co-occurrence network of keywords

Table 6 represents top 10 keywords with its percentage usage by authors. These keywords make up for 17% of all the keywords in the selected articles. The most used keyword is "Supply chain management" which represents around 18% of top 10 keywords, followed by risk management representing around 14% of top 10 keywords. This table illustrates relevance of this study since majority of the words emphasizes on management of various risks related to the supply chain along with the management required for tackling such vulnerabilities.

Table 6: Top Keywords

Words	Occurrences	%
supply chain management	152	17.82%
risk management	119	13.95%
supply chain	104	12.19%
supply chain risk management	90	10.55%
supply chain resilience	75	8.79%
resilience	74	8.68%
supply chain disruptions	69	8.09%
disruption	66	7.74%
supply chain disruption	55	6.45%
disruption management	49	5.74%

Citation Analysis

4.1 Citation Analysis

The purpose to implement this particular analysis was obtaining the ubiquity of a publication dependent on the frequency of its citation. Citation Analysis generally is quantified with the help two indexes: the global and local citations. The previous focuses on the total number of citations taken into consideration from other domains & exploration areas while the latter emphasizes on when one publication was cited by.

Table 7 illustrates the year wise citations in the field on SC resilience along with Mean total citation per article as well as mean total citation per year. Whereas, Table 8 represents top 10 publication based on Global Citations, the highest amongst these is Tang Cs, published in the year 2006 in the journal International Journal of Production Economics with 1192 citations followed by Tomlin B published in the year 2006, in the journal of Manage Science with 887 citations.

Table 7: Annual Total Citations

Year	N	Mean Total Citation (TC) per Article	MeanTCperYear
2006	15	174.73	12.48
2007	18	144.17	11.09
2008	20	113.35	9.45
2009	26	139.85	12.71
2010	28	85.18	8.52
2011	39	81.15	9.02
2012	47	44.19	5.52
2013	54	41.61	5.94
2014	67	33.03	5.50
2015	75	40.39	8.08
2016	78	21.37	5.34
2017	89	20.26	6.75
2018	122	12.30	6.15
2019	139	09.23	9.23

Table 8: Top 10 publications based on Global Citations

Paper	Total Citations
Tang cs, 2006, int j prod econ	1192
Tomlin b, 2006, manage sci	887
Craighead cw, 2007, decis sci	684
Braunscheidel mj, 2009, j oper manage	550
Ponomarov sy, 2009, int j logist manage	521
Manuj i, 2008, int j phys distrib logist manage	489
Klibi w, 2010, eur j oper res	459
Tang o, 2011, int j prod econ	453
Tang c, 2008, int j prod econ	431
Pettit tj, 2010, j bus logist	368

The primary emphasis of Citation analysis resides primarily on the acclaim of a specific review depending on the frequency of recurrence in the interested domain. Yet, the secondary aspect of 'prestige' is looked over. As a rule, it is found out by the recurrence or the occasions a distribution is referred to by some other exceptionally cited papers. PageRank is a logical and well-known ranking calculation to gauge fame and esteem regarding to a specific node in a network cited. Its inception refers back to when it was used for recommending higher quality web pages to consumers on the search engine like Google. Also, it seems viable to employ the algorithm of PageRank in order to determine publications with high fame and esteem. The PageRank score can be calculated as follows (Brin and Page 1998):

$$PR(A) = ((1 - d) / N) + d *((PR(T1) / C(T1)) + \ldots + (PR(Tn) / C(Tn))$$

where d=damping factor (0, 1) that refers to the fraction of random walks that continue to the propagate along with the citations, N signifies the aggregate number of publications in the network, and $C(Ti)$ is defined the citation times of the publication Ti. The top four publications (Tomlin, 2006; Craighead 2007; Ponomarov,2009 & Tang, 2006) which were determined on the basis of scores obtained are almost relevant to those based on global citations (Table 9).

Table 9: Top 10 pubs based on Page Rank

Paper	Total Citations	PageRank
Tomlin B, 2006, Manage Sci	887	0.036683544
Craighead Cw, 2007, Decis Sci	684	0.03531018
Ponomarov Sy, 2009, Int J Logist Manage	521	0.030895778
Tang Cs, 2006, Int J Prod Econ	1192	0.026782496
Pettit Tj, 2010, J Bus Logist	368	0.019730506
Manuj I, 2008, Int J Phys Distrib Logist Manage	489	0.015336431
Klibi W, 2010, Eur J Oper Res	459	0.014415485
Tang C, 2008, Int J Prod Econ	431	0.013603492
Tang O, 2011, Int J Prod Econ	453	0.013117937
Braunscheidel Mj, 2009, J Oper Manage	550	0.00484384

Table 10 illustrates most cited references with their respective citations. Also, table 11 illustrates the most cited sources along with the articles in which IJPR lead with 2096 articles followed by IJPE with 2025 articles

Table 10: Most Cited Reference

Rank	Cited References	Citations
1	Kleindorfer, P.R., Saad, G.H., Managing Disruption Risks in Supply Chains (2005) Production and Operations Management, 14 (1), Pp. 53-68	110
2	Tomlin, B., On the Value of Mitigation and Contingency Strategies for Managing Supply Chain Disruption Risks (2006) Management Science, 52 (5), Pp. 639-657	103
3	Craighead, C.W., Blackhurst, J., Rungtusanatham, M.J., Handfield, R.B., The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities (2007) Decision Sciences, 38 (1), Pp. 131-156	85
4	Tang, C.S., Perspectives in Supply Chain Risk Management (2006) International Journal of Production Economics, 103 (2), Pp. 451-488	79
5	Hendricks, K.B., Singhal, V.R., An Empirical Analysis of The Effect of Supply Chain Disruptions on Long-Run Stock Price Performance and Equity Risk of The Firm (2005) Production and Operations Management, 14 (1), Pp. 35-52	64
6	Ho, W., Zheng, T., Yildiz, H., Talluri, S., Supply Chain Risk Management: A Literature Review (2015) International Journal of Production Research, 53 (16), Pp. 5031-5069	57
7	Jttner, U., Maklan, S., Supply Chain Resilience in The Global Financial Crisis: An Empirical Study (2011) Supply Chain Management: An International Journal, 16 (4), Pp. 246-259	50
8	Hendricks, K.B., Singhal, V.R., Association Between Supply Chain Glitches and Operating Performance (2005) Management Science, 51 (5), Pp. 695-711	49
9	Blackhurst, J., Dunn, K.S., Craighead, C.W., An Empirically Derived Framework Of Global Supply Resiliency (2011) Journal Of Business Logistics, 32 (4), Pp. 374-391	47
10	Ponomarov, S.Y., Holcomb, M.C., Understanding The Concept Of Supply Chain Resilience (2009) The International Journal Of Logistics Management, 20 (1), Pp. 124-143	47

Table 11: Most Cited Sources

Sources	Articles
International Journal of Production Research	2096
International Journal of Production Economics	2025
Journal of Operations Management	1333
European Journal of Operational Research	1330
Management science	1103
Journal of Business Logistics	839
Supply Chain Management: An International Journal	794
International Journal of Production Economics	778
Omega	758
International Journal of Physical Distribution & Logistics Management	750

4.2 Reference co-citation analysis of Supply Chain Resilience

The concept of Co-citation, similar to the Bibliographic Coupling, can be explained as a semantic similitude measure for records that utilizes citation relationships. It is defined as "the frequency with which two documents are cited together by other documents". On the off

chance that in any event one other report cites to two documents in common manner, these records are supposed to be co-cited. The most important features are that, the more co-citations two documents gain, the higher their co-citation strength gets, which eventually means that the documents are semantically related. Figure 9 illustrates co-citation network of all the 984 articles with automatic layout, Louvain clustering algorithm.
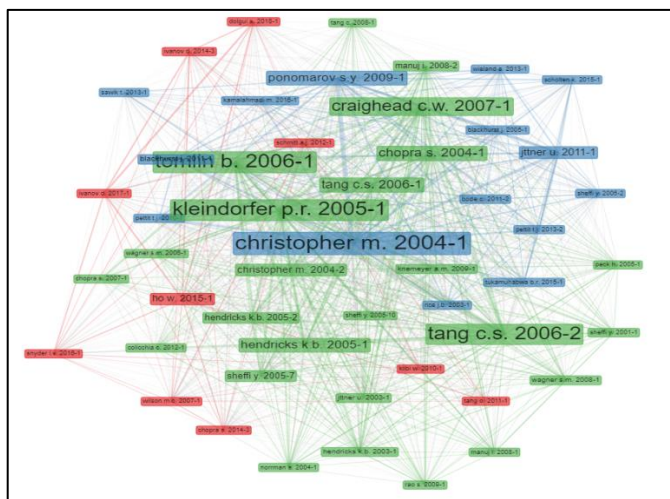

Fig. 8: Co-Citation Network

Table 12 indicates Top 10 country collaboration which collaborated for the objective of research in the field of SC Resilience, on the selected topic of supply chain resilience. Majority of all the obtained collaborations has happened between China & USA with the frequency of 38, followed by USA & UK with frequency of 24. India collaborated with USA for 8 times.

Table 12: Country Collaboration

From	To	Frequency
China	USA	38
USA	United Kingdom	24
France	Germany	20
China	Hong Kong	17
USA	Germany	14
China	United Kingdom	10
Iran	USA	10
USA	Canada	10
USA	Hong Kong	10
USA	India	8

Conclusion

We introduced the advancement going on in the field of Supply Chain Resilience in this paper relevant to the research cornerstone and prospective examination dependent on the Bibliometric strategy. The information necessary for this paper was gathered from the primary cluster of Scopus, out of which 984 related publications were chosen through filtering with respect to the required criteria. The annual exploration yield with respect to SC resilience shows that it consistently expanded from 2006 to 2020. Also, various extents of the current condition were supervised consisting of various apex journals, publication types, and co-occurrence network of categories. Additionally, to garner additional significant outcomes, assessment of Bibliometric, analysis relevant to co-citation as well as citation was directed.

Number of journal publications in the required field constantly improved from 2006 to 2016, but it exponentially grew from the span of 2017 to 2020. We obtained 233 sources (Journals & Books) with 984 documents included the publications about Supply Chain Resilience, amongst which 26.21% were being issued in 2% of the journals. The review that ranked at the pinnacle was "International Journal of Production Research" as per their yielded number of articles, Average citations per document were resulted to be as 33.41 whereas average citations per year per doc was observed to be 5.095 with 45580 references. 2011 authors were identified involved in the research topic of Supply Chain resilience with their keywords being obtained as 2461 keywords. The author appearances were observed as 2834 along with single authored documents as 84, while the authors of multi authored documents came out to be 1927. In the author collaboration categories, there were total 116 Single authored documents, at a rate of 0.489 document per author, whereas authors per document were 2.04 as well as the co-authors per document was 2.88. The Collaboration Index was found to be 2.22

In this paper, the fundamental commitments can be finished up as follows: Initially, a review regarding to the information composition and an improvement way in the area of SC resilience are introduced to enable researchers to catch latest research openings as well as construct various

novel perceptions. In particular, the adherence of leading publications, journals, creators, establishments, catchphrases etc. with respect to SC resilience was distinguished. Second, we finished up the potential exploration opportunities in the domain of SC resilience. This may prove to be valuable in acknowledging upcoming exploration hotspots while directing investigations with respect to SC resilience.

LIMITATIONS & SCOPE OF FURTHER RESEARCH

After performing this research and coming to different significant end results, there still remains a few limitations that should be tended to in upcoming work. Firstly, the information source, gathered from the primary cluster of Scopus, which can result in divergence in the consequences of Bibliometric examination. Many more publications viz. Google Scholar, ProQuest Dissertations, Theses etc. can be included to expand the source of information. In addition to this, many expert interactions or interviews can be employed in order to overcome this hindrance. Although research on Supply Chain Resilience was directed in a multifaceted manner (Figure 3), the emphasis was on the top five disciplines. Hence, the scope of research can be expanded further to include a blend of multiple disciplines. For instance, in Figure 3, even though environmental sciences represent a minimal share in the field of Supply Chain Resilience, it still possesses a large impact on vulnerabilities and risks which can further affect the decision-making of relevant stakeholders.

Moreover, a few disciplinaries which remains unincluded from the network of co-occurrence in Figure 3 possibly may be added in the upcoming years, for example, psychology. This can be useful in tackling many issues regarding various operational decisions which may result into disruptions, by considering certain psychological aspects such as optimism, pessimism & opportunism. This, in turn can help in measuring and exploring efficient & productive decision-making techniques for the retailers with multiple psychologies.

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