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RESEARCH ARTICLE

The Role of Collaborative Resource Sharing in Supply Chain Recovery During Disruptions: A Systematic Literature Review

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ABSTRACT The COVID-19 crisis has attracted attention worldwide to supply chain disruptions and resilience. Several supply chain risk management approaches have been revisited or reapplied in the literature; however, collaborative resource sharing is less researched. This study aimed to investigate the current academic state of the art and advances in using collaborative resource sharing as a reactive method to facilitate supply chain recovery in the presence of disruptive events. More specifically we considered the role of different collaborative resource-sharing strategies that organizations can adopt to support supply chain functionalities during times of disruption. We conducted a systematic literature review (SLR) to analyze academic articles that were published online from 2000 to 2022. In order to analyze the literature, we adopted a combination of text-mining, automatic and manual categorization of selected articles, and exploratory analyses such as cluster analysis and relational indicators. We also consider the machine learning classification algorithm i.e. agglomerative hierarchical clustering for the categorization of clusters. The findings show that, for disruptive risks, collaborative sharing of labour and material resources is effective for the recovery of supply chains. More so, labour resources tend to contribute more to the recovery of supply chains through the physical and mental recreation of recovery activities and experiences. Whilst information resources and a mix of information and material resources are highly important in reducing the impact of COVID-19 disruptive supply chain risk. In conclusion, collaborating on the three resources, namely labour, material, and information resources can be an effective post-disruption recovery strategy for supply chains.

INDEX TERMS Supply chain risk, supply chain disruption, collaborative recovery, collaborative resource sharing, hierarchical clustering, cluster analysis.

I. INTRODUCTION

The global supply chains have been vulnerable to disruptive events. This is due to the complexity of their functionalities and applications. Recently, the COVID-19 pandemic has contributed to the loss of over USD 1 billion in global supply chain activities and showed a revenue loss of about 13% on an annual average, with the possibility of further decline in the value of revenue [1]. Studies have highlighted the possible challenges that have warranted further decrease in revenue, these challenges include (i) lack of appropriate operational resilience and recovery mechanisms; (ii) possible rise in operating costs; (iii) feasible resource gaps that have resulted in slower response; and (iv) increasing cost of servicing IT systems [2]. For example, in terms of organization, assembly points of Apple were operating below capacity in a manner that most Apple points in Europe, South Korea, and Malaysia have been seriously affected by the global lockdowns and therefore hindered the interactions between suppliers and sub-suppliers [3].

Disruptive events are risks to supply chain operations [4]. Studies have mentioned that there are two main classifications of managing supply chain risk, namely proactive [5] and [6] and reactive strategies [7], [8], [9], [10], and [11].

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Proactive strategies are used to address issues of supply chain disruption. There are three main blocks of addressing disruption in supply chain namely preparation, mitigation, and response. Whilst, reactive strategies are used for supply chain recovery issues. Disruptive risks are unplanned activities. Therefore, recovering from their impact on supply chains remains an essential task. In the literature, several reactive strategies have been documented. For instance, the contingency practices [10]; alternative supplies [12], [13]; customer-supplier relationship management [14] and [15]; flexible logistics [16]; and collaborative resource sharing [17], [18]. An exhaustive list of reactive strategies used and the number of researches garnered by the paper are presented in Figure 1.

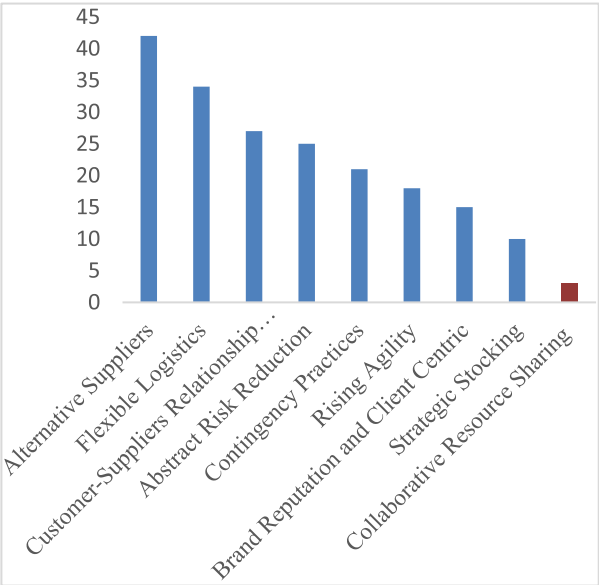

FIGURE 1. List of reactive strategies and contributors.

In Figure 1, it is evident that collaborative resource sharing (CRS) has been less researched. The main reason for the neglect is because collaborative resource sharing (CRS) allows for systematic combination and strategic change of the structural allocation of the resources by supply chain partners [19], [20], and the unparallel methodology requirements to conduct empirical research on horizontal collaboration due to differences in organizational assets, legal and physical resources [21].

Collaborative resource sharing is not new knowledge in supply chain management. However, its application is very limited. Bruning and Bendul [21] presented the importance of CRS by stating the benefits earned by supply chain partners through sharing of resources like equipment, personnel, and technology know-how. In particular, the work of Bruning et al. [22] shows that this method remains effective in case the supply chain is affected by disruption. However, it has not been given reasonable consideration in the literature. Additionally, collaborative resource sharing promotes the collaborative advantage achieved by partners of the supply chain during the recovery process from disruption [23]. Thereby it is imperative to present information on CRS for further research. Second, in the advent of disruptions, collaboration has been documented to be an effective measure. Conversely, how supply chain partners collaborate, on what type of resources, and how these resources are prioritized remain unanswered.

More so, with the recent developments such as the adverse effect of the pandemic on global activities and businesses, the need to offer insights into the role of collaborative resource sharing in the supply chain in disruption remains a concern. Therefore, the paper aims to proffer a better understanding of the role of collaborative resources during supply chain disruption. Specifically, the following research questions were raised to explain clearly the roles of CRS in managing the impact of disruption on the supply chain as described in the literature. The first research question is to examine based on the literature how do members of the supply chain collaborate to address the impact of disruption? The second research question is to explain, what types of resources are available to organizations to collaborate on during supply chain disruption? The third research question analysed, as presented by existing studies, is how do organizations deal with resource-sharing prioritization during a time of disruption?

The questions formulated by the paper enable readers to have a deeper understanding of the strategic way used by companies and supply chain partners to collaborate and ameliorate the impact of disruption on the supply chain. It also exposes the vast range of resources available to companies to collaborate on to improve the performance of their supply chain activities during disruptions. To situate the analyses, the paper categorized resources into three based on the submissions in the literature. The availability of this information will enhance the performances of managers and policymakers. More importantly, the ranking of shared resources as provided by existing research was also elucidated. Lastly, the paper developed a methodological framework to track trends in CRS research.

The paper proffers three main contributions to the existing studies on supply chain management. First, the paper investigated the submissions of existing literature on the role of collaborative resource sharing during and after a disruption occurs in the supply chain. This is necessary because the occurrence of disruptions requires organizations to look for an efficient way of responding to reduce the impact of disruptions. Second, the paper explored the literature to provide a better understanding of the types of resources that organizations have collaborated on during and after the disruption. Also, how these resources can foster recovery after disruption as described in the literature was also documented. This contribution is essential to aid the recovery of businesses and reduce the impact of disruption on the supply chain. Third, the paper examined the submissions of existing studies on the strategic combination of resources to appropriately respond to disruption and restore activities back to normal and even, to a better form.

Structure of the Paper: The remainder of the paper is organized in the following manner. Section II presents the research methods for preparing the systematic review of the literature, and section III presents the analyses and highlights the findings from the systematic review. Section IV presents the discussion and research agenda inferred from the review, while section V concludes the paper.

II. METHODOLOGY

The section discusses the method of analysis and the steps involved. This article utilized the systematic method of reviewing the literature. The systematic review follows the existing submissions made in the literature on supply chain collaboration, collaborative resource sharing, and supply chain disruption. The focus of this article is on how an appropriate organization can make a collaborative decision on available resources. It adopts three chronological procedures in the analyses (see Figure 2). This includes gathering articles, categorization and coalition, and exploratory procedure.

A. SEARCH PROCEDURE

Searching for articles is carried out using seven major publication archives namely *Elsevier, Taylor and Francis, Google Scholar, Scopus, Web of Science, Springer*, and the *University of Strathclyde SUPrimo*. These publication databases are considered because they have an adequate compilation of relevant articles. Articles were considered based on a publication timeframe that varies between 2000 and 2022. The reasons for considering this publication duration are: first, little recognition has been given to collaborative resource sharing before 2000, and second, the inclusion of papers before 2000 may result in the bias of analytical interpretation of findings and a significant change in the risk management strategy.

To maintain that selected articles are of a high standard, the paper restricts the search procedure within the confine of these seven publication outlets, and, ensures that only journal articles were considered. More so, these publication outlets hold large content of relevant articles. Table 1 presents the keywords used for the search of articles. Based on these keywords, 235 articles were grouped and tagged as Group 1. These articles in Group 1 were used for the analysis systematically.

In Table 1, the main keywords used for the search are displayed. The keywords rested on the three identified subjects selected based on their likely relationship with collaborative resource sharing. Table 2 shows the number of articles generated from each of the keywords.

Table 2 collates the articles collected from the prescribed queries. These articles provide updates on the growing number of publications in areas of collaboration, collaborative recovery strategies, collaborative resource sharing, and reactive strategies. Out of the total articles collected, Supply Chain Collaborations and Collaborative recovery accounted for 11.5% of the articles found. While the articles retrieved from queries on the collaborative resource sharing and resource sharing keywords are 43.8%. This has offered the paper the flexibility of adopting multi-layers categorization whereby allowing the paper to group and re-group the articles to contain the relevant articles that address the research questions raised.

TABLE 1. Keywords adopted in the search and restrictions.

Selected subjects	Main Keywords
Business OR Management Research	Supply chain collaboration AND collaborative recovery
	Supply chain collaboration AND SC Resilience
	Supply Chain AND Supply Chain Collaboration
Operational research	Collaborative Resource Sharing AND SCC
	Collaborative Recovery AND Resource Sharing
Management science	Collaborative Resource Sharing * supply chain
	Resource Sharing AND Reactive risk management
	Collaborative Resource sharing AND Reactive risk management

B. CATEGORIZATION AND COALITION

As said, the journal articles were garnered and collated for screening using the inclusion criteria designed for article selection. These articles were later categorized through manual and automatic categorizations. The former was arranged on the selection criteria set forth, while the latter is relying on the text-mining algorithm used by the software used for the analysis. Brief descriptions of these categorizations are expressed for methodology clarity.

1) MANUAL CATEGORIZATION OF SELECTED ARTICLES

The manual categorization used in the paper follows three main procedures. The first procedure focuses on the *global screening* of collected articles (i.e. 235 articles). The global screening is performed on the total articles (Group 1). The group is a collection of articles that have adopted empirical modeling to present issues relating to supply chain collaboration and collaborative resource sharing. The categorization was later streamlined to redefine the filtering to articles that are specific to the interest of the paper. This is termed *specific screening*. The number of articles that falls under this category is 215 articles after some articles have been excluded based on certain keywords, for example, keywords '"proactive risk' and 'reactive risk management'" were excluded. The reason for the exclusion of proactive and reactive risk management is to narrow the scope of the search

TABLE 2. Articles generated by keywords and sub-keywords.

Main Keywords	Sub-Keywords	Number of Articles
Supply Chain Collaborations and Collaborative Recovery	Supply chain collaboration	22
	Collaborative Recovery	5
Supply Chain Collaboration and Supply Chain Resilience	Supply Resilience	7
	Supply Chain	7
	Supply chain collaboration AND Resilience	10
Supply Chain Collaboration	Collaboration	18
	Supply Chain*Resource Sharing	14
Collaborative Resource Sharing and SCC	Collaboration AND Recovery	2
	Collaborative Resource Sharing	3
	Collaboration AND Recovery Strategies	16
	Supply Chain Collaboration AND Recovery	14
Collaborative Recovery and Resource Sharing	Resource Sharing	12
	Collaborative Resource	8
Collaborative Resource Sharing Supply Chain	Supply Chain AND Collaboration	16
	Resource Sharing AND Collaboration	10
Resource Sharing and Reactive risk management	Reactive Strategies AND Risk	15
	Risk Management AND Reactive	14
Collaborative Resource Sharing and Reactive risk management	Resource Sharing AND Collaborative Strategy	18
	Collaboration*Risk Management	9
	Reactive Risk Management	15

to collaborative resource sharing and recovery of supply chains, Hence, 203 articles made up sub-group I.

The third procedure follows the approach proposed by Cao et al. [24]. This procedure involves performing a *second-order filtering technique* that allows re-ordering of screening keywords to go in line with the interest of the paper, as it examines how applicable is collaborative resource sharing in the literature. The screening keywords used are resource sharing, collaborative recovery, information as a resource, sharing of information resources, collaborative communication, and incentive alignment. The paper ensures that the second-order filter mapped out the aim of the research. This category is termed sub-group 2 and contains 195 articles.

With the application of an appropriate screening and categorization process, the research framework shows that about 17% of the articles garnered in Group 1 were not keenly relevant to the research interest and were dropped. Therefore 83% of the articles that have been collected were used for the exploratory analysis of the paper. The inquisition into the role of collaborative resource sharing was carried out using the resource types available to organizations. These resources are material resources, labour resources, and information resources.

2) AUTOMATIC CATEGORIZATION OF SELECTED ARTICLES

This involves the categorization of articles based on the text-mining algorithm present in the NVivo qualitative analysis software used (Table 3). The categorization was performed on the initial articles collected i.e. Group 1 articles. The coding activities in NVivo were conducted through a text-search query that allows multiple selections of sets of keywords.

Articles that have the likelihood of containing the main keywords of the research interest were coded in the NVivo word nodes for further mining queries. In the software, the '*term frequency*' technique is used for retrieving articles that are widely related to the research interest. This technique is the most appropriate to text-mine information because of the peculiar nature of initial article gathering and search. In the initial search, the paper has ensured that the selection follows the research interest, and this can be inferred from the keywords adopted. Again, every article in the sub-groups identified by the mining outputs has its respective designated term. This serves as a unique identifier for each of the articles in Group 1 and shows how they were systematically filtered to the last sub-group used for the exploratory analysis. The systematic filtering technique stems from the *term frequency* formula in equation (1).

$$TF_i = TF_{t,d} \ * \ \log\left[|D|/DF_{t,d}\right] + IDF \tag{1}$$

where TF is defined as the *term frequency* of i *and* d, which is the same as the frequency of occurrence i *and* d. D is the size of articles, and DF is the frequency of the document in question. In other words, the frequency of documents where 't' appears in D [68], [69].

The filtering method is based on the *term frequency* (TF) estimated from the specific word node, and each of the categories was filtered with the varying sub-categories. Articles that belong to the word node of category I with a TF value that is high were selected among the articles in the same node. The high TF estimate indicates that the article in question is a main article within the sub-categories listed.

3) EXPLORATORY PROCEDURES

The exploratory procedures adopted in this paper are cluster analysis and relational analysis. The cluster analysis allows the grouping of a set of defined categories that share similar

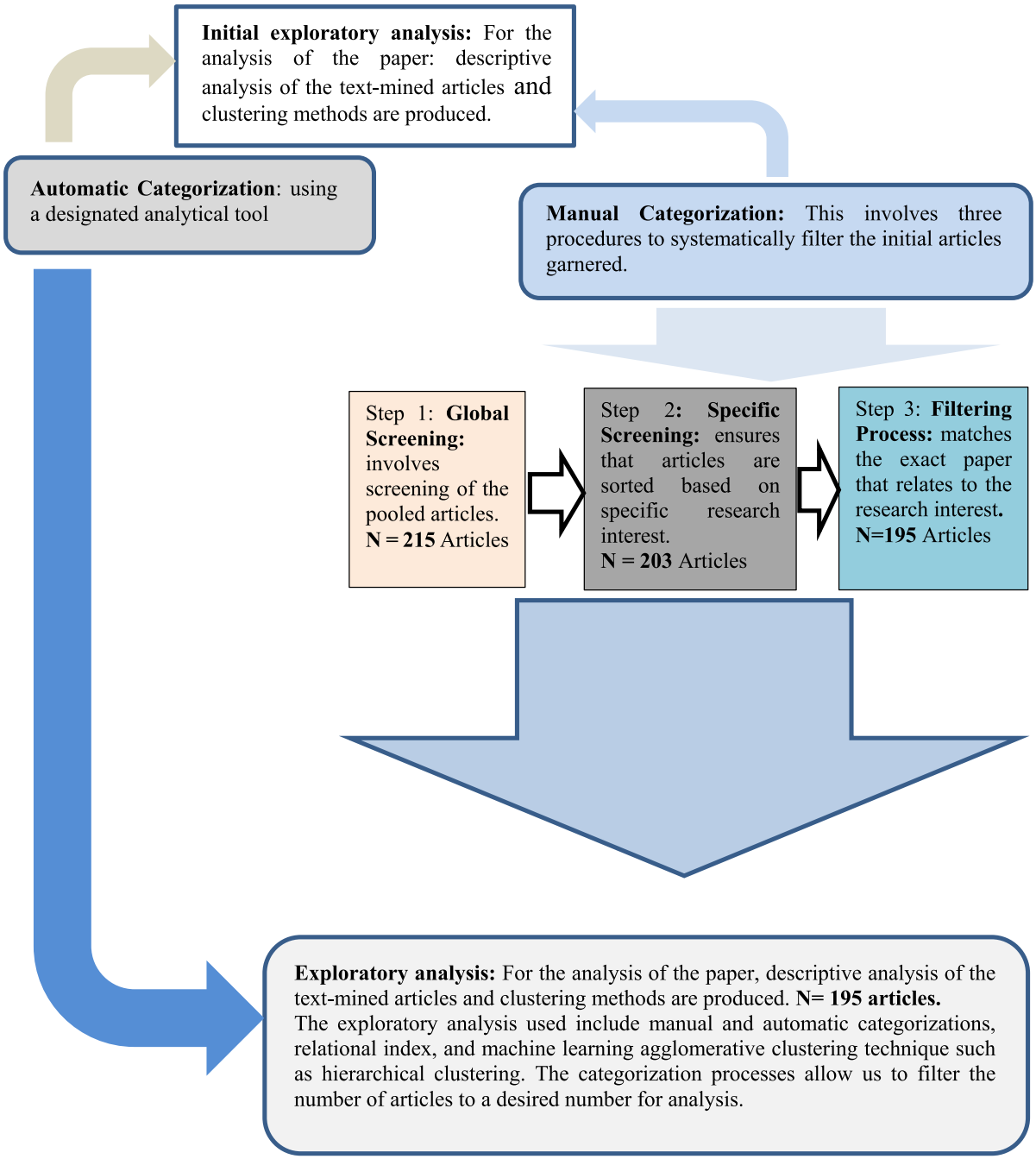

FIGURE 2. The search framework.

attributes (i.e. identified sub-categories). For a better presentation of the clustering among defined attributes, the paper employs the hierarchical cluster analysis, which has been proven to be superior to GARCH volatility clustering that only accounts for time series datasets, and is more appropriate for the classification of categorical analysis. Besides, it is one of the classification approaches in the machine learning method [25] and [26]. To correct the impact of binary information, the paper adopts the unweighted pair group method with arithmetic mean. The main reason for selecting the unweighted method is because of its ability to report the similarity coefficient for binary observation based on its algorithm and the Jaccard similarity index [27] and [28].

The binary series was generated from sub-group 2. If an article within the sub-group 2 is assigned '1' in the row object of the sub-group then, it implies that the column is assigned the same value, otherwise 0. The $[N \, x \, N]$ matrix set is used for the estimation of the similarity of each pair of articles in the category. The hierarchical clustering technique was complemented with the Jaccard similarity measures to estimate the closeness among the clusters. The relational analysis was performed using the relationship index. The relational value

TABLE 3. Nvivo text-mining keywords.

Categories	Sub-Categories	Keywords for text-mining
Interest	I_1	'supply collaboration' ~ 2 OR 'supply chain collaboration
	I_2	'supply collaboration' ~ 2 OR 'collaborative recovery'
	I_3	'collaboration' ~ 2 OR 'collaborative recovery'
	I_4	'collaborative recovery' ~ 2 OR 'collaborative resource sharing
	I_5	'collaborative resource sharing' ~ 2 OR 'resource sharing'
Subject	S_1	food*food and drug
	S_2	health*health sector and COVID-19 Disruptions
	S_3	medicine*pharma*OR drug*COVID-19 Disruptions
	S_4	manufacturing*manufacturing products
	S_5	business*OR operational research
	S_6	'supply chain recovery*OR supply chain resilience

of an article is used to rank the article and compare it with other articles in the sub-category. The relational index further shows the importance of collaborative resource sharing. The formula for the calculation is given as follows.

$$RI = \frac{\sum_{j=1}^{j=5} NoA_j * \omega_j}{NoA\ in\ the\ cluster} \tag{2}$$

Note: NoA is the total number of papers collected and is scaled based on the Likert scale 1-5. The scale is to allocate weight to each type of collaborative resource. The decision rule for the relationship index is between 1 and 2 i.e. $|1 < RI < 2|$. Intuitively, if RI <1, then the relationship index states that RI is low. If it is less than 2 but greater than 1, then we conclude that RI is middle, and high if the relationship index is greater than 2. NOA in the cluster is the total number of papers in the cluster (sub-group). The analyses are conducted through Python 3.0 programming software that was used for the hierarchical clustering and NVivo qualitative software for the automatic categorization and relational analyses, respectively.

III. FINDINGS AND ANALYSIS

A. DISTRIBUTION ANALYSIS OF ARTICLES (BASED ON PUBLICATION YEAR AND SECTORS)

An overview of article distribution within the timeframe of publication is presented in Figure 3. In 2014, the distribution shows that research on supply chain collaboration has attracted more attention among researchers. The interest remains strong among researchers and organizations as the effect of the global pandemic bites harder. Collaborative resource sharing came into the debate in late 2010. Most of the related research started by introducing resource sharing within the unilateral context that is a '*firm-internal application*'. Afterward, the sharing of resources evolves beyond labour resources, and as supply chain operations got more complex, material resources were shared among departments to meet organizational goals

With the advent of information technology bubbles, information resources became one of the resources that facilitate sharing of other resources such as labour and materials. Besides, information itself is a resource that is shared within the organization to facilitate the delivery of goods and services and meet operational targets. The decline in the number of research papers in 2020 compared to 2019 was attributed to researchers' interest in the compounding aspects of collaboration. From the distribution, it was apparent that three main resource types are shared by organizations either independently or collaboratively. These resources are labour resources, material resources, and information resources. These types of resources are used as a baseline for classification in cluster analysis.

The distribution of articles according to sectors is presented in Figure 4. The manufacturing sector remains the sector where collaboration and collaborative sharing of resources are highly applied. The sector consists of companies that produce goods such as food, automobiles, and drugs, among others. This is followed by the transportation sector which accounted for about 25% of the total papers considered for the analysis. Out of the 25%, 23 articles directly make use of the logistic sub-sector. 38 articles concentrated on the hospitality sub-sector and a significant part of the articles focus on hotels and tourism, respectively. The health sub-sector accounted for 3.7% of the total number of articles considered by the research. In the sorted sample, the pharmaceutical industry was classified as manufacturing because it specializes in the production of medicines. However, medical centres and hospitals are classified under the healthcare sub-sector which is extracted from the broad service sector alongside the hospitality industry.

B. DISTRIBUTION ANALYSIS OF ARTICLES (BASED ON CATEGORY AND SUB-CATEGORY)

Following the *term frequency* approach for article extraction. Articles in sub-group 2 were extracted and classified into sub-categories based on the interest and subject headings. The numbers of articles in each sub-category and their percentages were depicted in Table 4. In the interest category (I), articles on 'supply chain collaboration and supply collaboration' dominated the articles under the category. Whilst, articles on collaborative recovery and collaborative resource sharing are sparsely documented, the paper makes considerable efforts to ensure that a significant number of articles on this theme were included. This is because the sub-category (I_4) is one of the themes that explain the role of collaborative

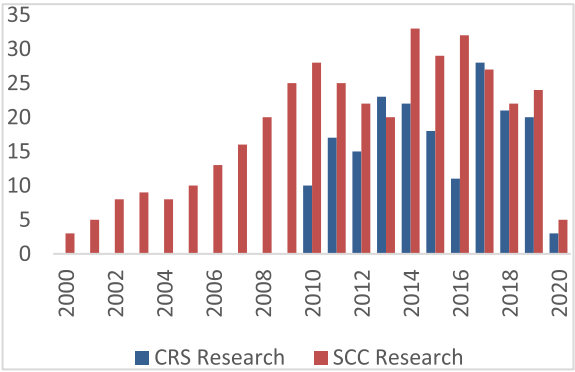

FIGURE 3. Distribution of articles in group 1 and subgroup 2.

TABLE 4. Articles distribution by category and sub-categories.

Categories	Sub-Categories	% Distribution of CRS Articles in sub-group 2
Interest	I_1	28 (14.5%)
	I_2	15 (7.77%)
	I_3	18 (9.32%)
	I_4	25 (12.95%)
	I_5	17 (8.80%)
Subject	S_1	13 (6.73%)
	S_2	9 (4.66%)
	S_3	5 (2.59%)
	S_4	29 (15.02%)
	S_5	27 (13.98%)
	S_6	7(3.62%)

resource sharing in managing the supply chain in disruption. In the subject category (S), many of the articles under the category address the issue of supply chain disruption in the manufacturing sector and business and operational research. Nonetheless, articles on the health sub-sector supply chain and other related issues such as medical care, healthcare homes, and drug administration were sparsely represented (less than 3%).

C. DISTRIBUTION ANALYSIS OF ARTICLES (BASED ON CLUSTERS AND RELATIONAL LINKS)

Based on the hierarchical cluster analysis of the extracted articles, three major clusters were identified for collaborative resource sharing. These are collaborative resource sharing (CRS) on labour resources (cluster 1); CRS on material resources (cluster 2); and CRS on information resources (cluster 3). Surprisingly, the intersection path of the article in one cluster falling in another and within sub-categories was observed. These show the significant level of dynamism that exists in each of the clusters. The relationships among the clusters are unequal, which indicates that the use of the relationship index may not be appropriate to design the link, especially when dealing with small sub-categories and clusters.

Meanwhile, both labour and material resources are characterized by a moderate level of collaboration when shared. Collaboration on sharing information resources was relatively low. This is because a limited number of articles were available at the time of developing the research paper, and the automation of supply chain operations in business organizations was weakly embraced.

D. DISTRIBUTION ANALYSIS OF ARTICLES (BASED ON COVID-19 PAPERS AND RELATIONAL LINKS)

The section presents the cluster analyses of shared resources in addressing the adverse effects of the pandemic on supply chain activities. The cluster analysis is conducted based on the relationship index (Table 5). Cluster and relational analyses were performed based on Jaccard simulation and relationship index. Cluster 1 is defined as CRS on labour resources, Cluster 2 is defined as CRS on material resources, and Cluster 3 is defined as CRS on information resources. The result indicates that to effectively reduce the impact of COVID-19 disruption on supply chains, collaboration on the sharing of material resources is greatly acknowledged. Although the combination of material and information resources proves more effective, however, the importance of digital resources in the information resource segment is less utilized. The main reason highlighted in the literature used is that the adventure of digitalizing activities within the supply chains especially manufacturing supply chains has witnessed limited exploration. The analyses also revealed that collaboration on labour resources may not be effective in combating the menace of COVID-19 disruption on the supply chain.

Furthermore, studies have recognized other mitigation strategies apart from CRS, and these are classified into four main parts (Table 6). These parts consist of supply management, inventory buffering, information acquisition and visibility, and digitalization. The management of supplies had been discussed in the context of flexibility, multiple sources, and securing several alternatives for receiving supplies [29], [30], [31]. On inventory buffering, existing studies have reckoned with stockpiling of inventory Tomlin and Wang, redundancies in stock [32], [33], and lean resilience [19].

While some of the strategies within supply management and inventory buffering have been documented before the COVID-19 disruptions, however, digitalization and information acquisition and visibility have become the normal norms. The advent of the COVID-19 pandemic has posed increasing pressure to digitalize most activities along the supply chain. Studies that have recommended the digitalization of production and logistic segments of supply chains [34], [35], and emphasis on digitalizing the major activities along the supply chain network have had greater acceptance [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36].

TABLE 5. Cluster analyses of shared resources (based on identified resource types).

Distribution of Articles not related to COVID-19			
No. of Clusters	**No of Articles**	**Relationship Index**	**Interpretation**
Cluster 1	93	1.19	Medium level of collaboration on labour resources
Cluster 2	63	1.37	Medium level of collaboration on available material resources
Cluster 3	39	0.92	Low level of collaboration on the sharing of information resources
Distribution of Articles related to COVID-19			
No. of Clusters	**No of Articles**	**Relationship Index**	**Interpretation**
Cluster 1	10	0.73	Low level of collaboration on labour resources
Cluster 2	12	1.18	Medium level of collaboration on available material resources
Cluster 3	8	0.82	Low level of collaboration on the sharing of information resources

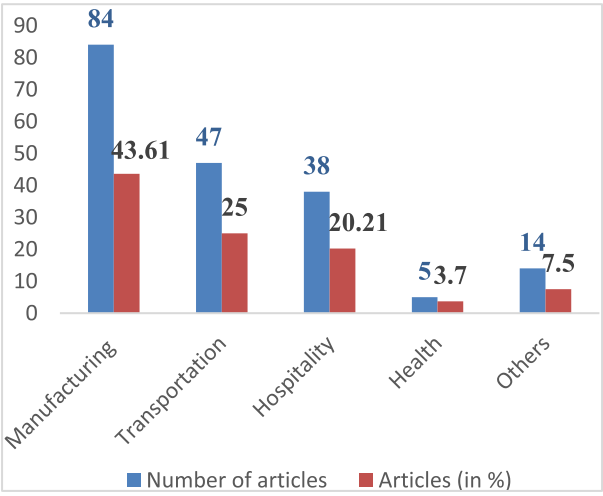

FIGURE 4. Distribution of articles by sectors.

E. ANALYSES OF POLICY DIMENSIONS AND THRUSTS OF THE RESEARCH

The paper raised three main research questions to explore the policy dimensions and thrusts of collaborative resource sharing.

F. HOW DO SUPPLY CHAIN MEMBERS COLLABORATE?

The first research question discusses how supply chain members collaborate. Reviewed literature had polarized forms of collaboration into vertical and horizontal collaboration. Vertical collaboration refers to the union of supply chain members across different departments of an organization. This is particularly internal to the organization [37]. These types of collaboration have been discussed by different authors and submissions [38], [39], [40], [41], [42]. According to Cao et al [24], collaboration among supply chain members provides resilience to disruption because of seven interconnected elements that are made available to participating members during disruption. These elements consist of information, unified target, integrated decision, efficient communication, strategic resource allocation, creativity, and incentive alignments.

Cao et al [43] opined that the stronger are organizations when they collaborate on supply chain operations faced with disruptive events. [44], [45] emphasized these elements by directing their application to build up classification in a collaborative manner among supply chain members. Scholten and Schilder [46] as pointed out that these elements facilitate successful collaboration among internal units of an organization. They believed that when supply chain members understand that collaboration over these identified elements could spot the possible impact of disruptive events on supply chain operations, that allows organizations to beef up preparations for collaborations and possibly reduce the impact of disruptions. Vertical collaboration can co-exist between suppliers and customers of an organization.

In the research findings of Rapaccini et al [47], suppliers and customers interact throughout the organization and their collaboration can assist companies to understand market dynamics such as forecasting the possible market bubbles and bursts that could strengthen disruptive activities and heighten the impact on supply chain operations. This claim was supported by [48]. Internal collaboration occurs between departments and subsidiaries of an organization [49], [50]. Studies have presented the application of vertical collaboration in several sectors of the economy. In the findings of Belhadi et al [35], vertical collaboration is effective in improving the performance of the manufacturer's supply chain during disruption. In the research, they considered the supply deficiency of manufacturing companies during COVID-19-related disruptions.

Studies that have explained that information sharing and coordination have been the strong element of the e-commerce sector during disruption include [51], [52], [53], [54], and [55]. Simatupang and Sridharan [56], places more importance on the transformation of available resources and a clear understanding of the performance condition. Karmaker et al [57] further present the application of vertical collaboration using the integrated model in the advent of COVID-19 pandemic. They applied integrated models to explain how to improve supply chain sustainability in an emerging sector and economy.

TABLE 6. Supply chain functionalities (recommended strategies after COVID-19).

Supply Chain Functionalities			
Supply Management	**Inventory Buffering**	**Information Acquisition and Visibility (IA&V[1])**	**Digitalization**
• Flexible supply and alternative sources [183] • Localization of supply sources [188] • Localization of supply chain and base [152]; [194]; and [40] – [41]	• Inventory buffering [21]; and [183] • Lean resilience [95]	• Information processing capabilities [190] and [191] • Supply chain visibility [121] and [124] • Active information sharing [182] and [183]	• Supply chain digitalization [104]; [107] • Digital twin [99] and [96]

The argument of Lee et al. [58] states that organizations earned value from business resources they do not own or control, this pointed toward the importance of collaborating horizontally. Horizontal collaboration refers to the amalgamation of two or more supply chain members over pooled resources to address the issue of supply chain disruption [59]. This typology of collaborative efforts had been identified in the literature [19], [60], and [61], however little attention has been given to it and its application has been quite scanty if not available. Instead, studies have stressed the definition of supply chain collaboration. Supply Chain Collaboration is defined as the coming together of two or more independent organizations to plan and execute supply chain operations to achieve improved performance better than operating in isolation [52] p.19.

Building sustainable resilience around supply chains has been one of the panaceas to strengthen the functioning of supply chains in disruptions. The benefits of collaboration also included collaborating horizontally. As highlighted in the literature, performance improvement [61], service quality [62], and cost reduction are feasible benefits of collaboration either vertically or horizontally [63]. Messina et al [64] stated that collaboration is used to mitigate risk, as it deals with demand amplification in the supply chains. As buttressed by Lee et al. [65], increased collaboration has facilitated the realization of rationing and amplification of the supply chain. As deduced from the description in the literature, the styles of collaborations are classified into four and depicted in Figure 5.

Both vertical and horizontal collaborations are dependent on the two methodological processes of supply chain collaboration. These are proactive and reactive approaches. The reactive approach is considered after the occurrence of disruptive events. Hence, reactive approaches are applied during recovery to return to normalcy in operation. The main aim of the reactive approach is to reduce the severity of disruptions in line with the recovery time and associated costs [66], [67]. Studies have provided submissions on the application of reactive approaches. Some of these studies have adopted contingency practices [10], flexible logistics [68], [69] and [70], and alternate suppliers [12], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [70], and [71]. Norrman and Jansson [15] also stated the importance of strengthening supplier-customer relationships as a reactive approach.

In practice, organizations use proactive and reactive approaches intermittently. Organizations employ proactive methods to prepare themselves for uncertainties or unforeseen circumstances. These preparations are actions employed to better understand and respond to disruptions when they occur [72], [73]. This means that proactive and reactive in most cases cannot be discussed separately. Consequently, some approaches intersect the boundaries of proactive and reactive approaches [9].

The reactive approach had earned considerably little attention compared to the proactive methods in the literature. According to Ghadge et al [73], 56% of the reviews concentrate on the application of proactive measures, while 21% adopted holistic approaches. Only 23% of existing studies make use of reactive measures. The work of Sodhi et al [56] also buttressed the findings of Ghadge et al [73], as it found that reactive methods are less researched. Tukamuhabwa et al., [74] found similar submissions on the lack of reactive strategies in the literature. The absence of the application of reactive methods signifies a research opportunity.

G. WHAT TYPE OF RESOURCES DO ORGANIZATIONS COLLABORATE ON?

The second research question raised focuses on the type of resources organizations collaborate on during supply chain disruption. Several submissions in this regard have identified the important role of these resources in fostering the recovery

of the supply chain during disruptions [75], [76], [77], [78]. These resources cut across stages of organizational assets, and as a result, the categorization of these resources was made in this paper to redesign the resource in a manner to capture more of these resources rather than discussing them in their fragmented form as reported in research submissions. The paper categorized resources highlighted in the literature into main three headings namely labour resources, material resources, and information resources. These categorizations are defined in cluster form, for instance, cluster 1 refers to the collaborative sharing of labour resources; cluster 2 is the collaborative sharing of material resources, and cluster 3 is defined as the collaborative sharing of information resources. The review of the resources is conducted alongside these categorizations.

Cluster 1 (CRS on Labour Resources): In terms of facilitating collaborative recovery, labour resource plays a significant role in the coordination of the supply chain to achieve organizational objectives [79] and [80]. Unlike the process of operating as a competing supply chain, studies have shown that labour resources are involved in the coordination of supply chain activities. For instance, in the manufacturing supply chain, activities along the chain process necessitate effective interaction among suppliers, organizational employees, and customers. The cordial interaction, portends the strength and smooth collaborative efforts available to the organization to recover the supply chain in disruptions [81], [82], [83], [84].

Studies classified organizational employees into skilled (managers and professionals), semi-skilled, and unskilled manpower. These are known as specific labour resources [85], [86], [87], [88]. One of the specific cases cited in the literature to explain how companies collaborate through labour resources to overcome threatening moves of disruptive events is the case of about 2,500 employees that were shared among organizations in the industry to facilitate Renesas' recovery [89], [90]. Again, Toyota has to relieve about 400 of its employees from several units and departments to promote Aisin's recovery [91]. Other categorizations of specific resources as mentioned in the literature are community resources such as environmental and social resources, and knowledge transfers. In sharing the resources, organizations do set up operational policies to guide the shared resources within and among organizations. Hence, setting up operational policy is highly regarded in the literature [88] and [92].

Literature has classified sharing of labour resources into three main units namely the production unit, logistics unit, and inventory unit, respectively [93] and [94]. In the production unit, labour resources were reorganized to meet pent-up demand, and supply shortages, and to support the existing mechanical system shutdown. Employees with relevant skills were deployed from other departments to support production activities. These employees are compensated for the extra assignments, which are termed motivational incentives [95] and [96].

Motivational incentives are short-term incentives given to employees that are used to support other units in the workplace to address organizational supply issues [96]. The incentives are paid to employees to compensate for their exceptional skills used in overcoming supply shortages or production disruptions [9]. The health implication of collaboration for employees cannot be overemphasized.

Existing employees are not overworked as a result of Inventory unit employees are also re-trained to ensure they earned the same knowledge base as the new employees joining them from other units on a temporary note, and for emphasis. In this regard, 8 articles were found offering direct discussion on the inventory unit and specifically the issue of the bullwhip effect and supply chain operation. Figure 6 shows the relational diagram of collaboration on labour resources.

Cluster 2 (CRS on Material Resources): Apart from labour resources, organizations collaborate on material resources to revive the supply chain from the impact of disruption. The review states that material resources that organizations collaborate on during disruption are divided into two major groups namely tangible and intangible resources. The tangible resources consist of warehouses, tools, facilities, pieces of machinery and other equipment, and logistics services among others. While the intangible assets are information sharing, reputations, and interactions and relationships. These resources are not only applicable in the recovery of the supply chain encountering disruption in the production unit, their application cuts across all organizational units as long as they are faced with disruptive events that affect the supply chain to perform optimally. For instance, tangible resources such as facilities, tools, and pieces of machinery are used up for factory repairs during the western digital recovery [60] and [98].

Also, organizations in the food industry make use of machines, logistical services, and warehouses of competitors to facilitate the recovery of their supply chain during the recent pandemic disruption. This has addressed the production disruption issue that the organization faces. Through collaboration, moderation of work activities is maintained in the production unit, and this reduces the persistence of disruptive events. After the second filtering of articles, *subgroup 2* contains 13 articles that discussed the application of sharing labour resources collaboratively in the production unit. These articles presented cases of manufacturing and e-commerce setups. In the logistics and inventory units, collaborative sharing of labour resources is profound in the distribution sub-units [99], [100], [101], and [102]. For example, the contributions of Yildiz, Ravi, and Fairey [101] and Banerjee [100] portend that transportation activities between suppliers and customers specifically strategies to optimize capacity in inbound and outbound routes are relevant to portray the activities of labour resources and their collaboration to attend to disruptive issues. In total, 11 articles were retrieved on logistics research after the second filtering.

In the inventory unit, organizations collaborate on labour resources to address specific issues that affected supply chain operations. A well-known inventory issue identified in the

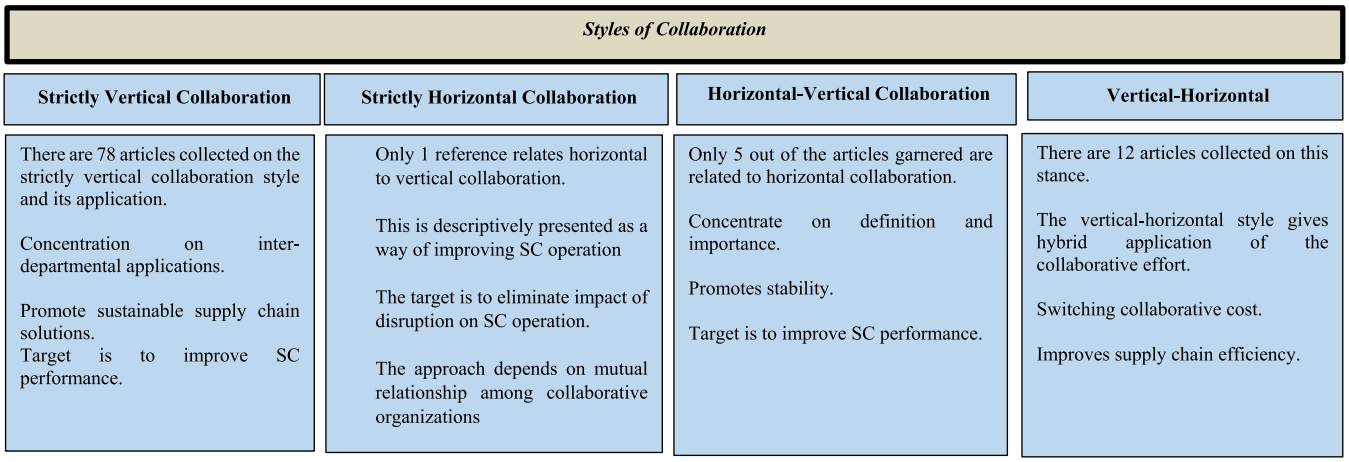

FIGURE 5. Styles of collaboration.

literature is the bullwhip effect. Organizations address these inventory issues by offering relevant pieces of training to interested employees in other departments on the measures and management of bullwhip issues [103].

Collaboration on tangible resources is complemented with the use of intangible resources such as information and communication sharing; and interactions and close relationships among departments and departmental heads [104], [105], and [10]. For example, during Riken's recovery, customers are sent aid supplies through established relationships and interactions [104], and the recent collaboration of two giant retail stores to reduce the impact of the COVID-19 pandemic on the household goods supply chain is conducted based on mixed of intangible resources (such as reputation and relationships) and tangible resources (such as logistical services and warehouse capacities).

The second filtering shows that 17 articles are available in this category of collaborative effort. These articles pointed out that collaboration over material resources is important for the fast recovery of supply chains in disruptions [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92], [93], [94], [95], [96], [97], [98], [99], [100], [101], [102], [103], [104], [105], [106], [107], [108]. These studies have classified shared resources within the material resources under the following themes: sharing of production materials, sharing of procurement materials, sharing of supplier capacity, and sharing of the production facility, among others.

Cluster 3 (CRS on Information Resources): Sharing of information comprises the ability of the organization to disseminate critical data that will facilitate production plans. In the supply chain, information sharing had promoted end-to-end visibility along the chain process [65], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92], [93], [94], [95], [96], [97], [98], [99], [100], [101], [102], [103], [104], [105], [106], [107], [108], [109]. Although the application of recent information-sharing devices such as blockchain, and artificial intelligence have aided the recovery process of the supply chain in disruptions [110] and [111], but will require a significant change in the design and manner in which the supply chain operates [98]. Substantial references have pointed to the contributions of information and communication technology and information materials as the main information resources used up by organizations in the process of recovering the supply chain in the wake of fatal disruptions [98].

Several areas have been identified by existing studies on the collaborative manner of applying information resources to support other resources in the industry to promote faster recovery of supply chains. Notable of these applications include product traceability and elimination of redundancy; enhanced supply chain visibility and security; and reduced intermediation that delays supply chain operation and information security along the chain processes [112] and [113]. Organizations collaborate to develop strong information-sharing platforms during disruptions. For instance, Provenance and Everledger shares information-based platforms that show the provenance of food products and ensure activities can be monitored for safe delivery. This enhances trust in the exchange of information between the two companies and such that information about activities carried out in the supply is easily shared. These activities include when, where, and by whom production stages were implemented and which logistic partner is engaged, and when and where [114] and [115]. An exhaustive list of how, method, and where supply chain members collaborate during disruption is presented in Table 7.

More so, Maersk worked for IBM on the digitalization of maritime trade. In this information-sharing platform, the end-to-end visibility of the supply chain remains the main facility embarked on in the project. The project is termed the

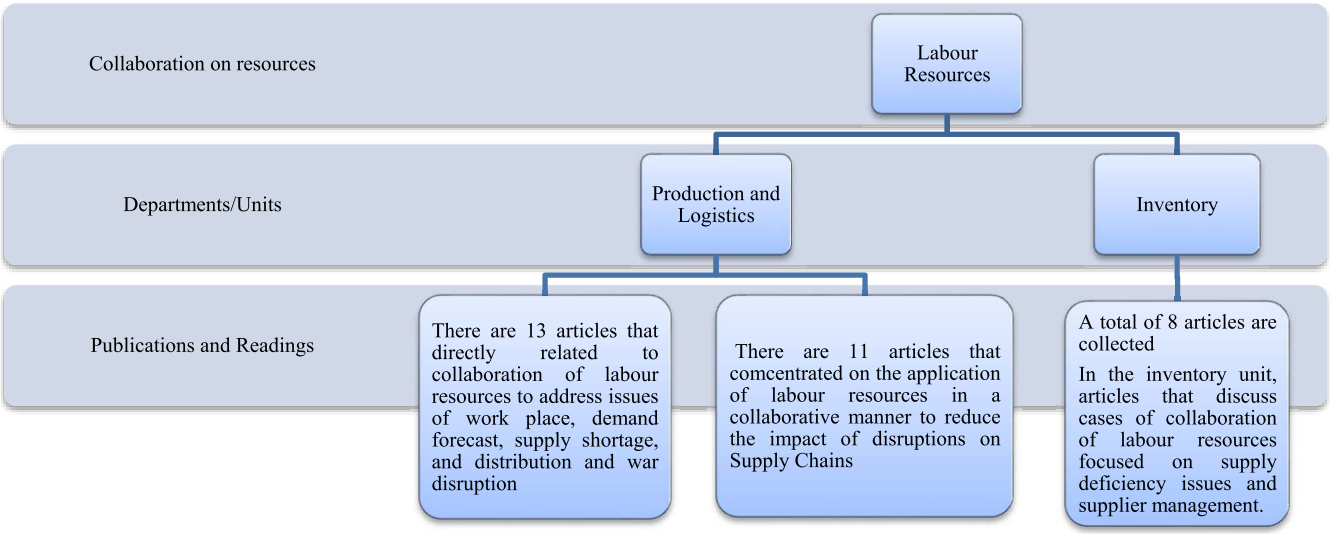

FIGURE 6. Relational diagram on collaboration of labour.

TABLE 7. Collaborative typology of supply chain members.

Collaborative Efforts	Description of collaborative styles and related publications	Collaborative (Risk) Methods	Sectors where collaborative styles have been applied	Descriptions of the composition of case studies under each of the identified sectors and related publications
Vertical Collaboration	*Strictly Vertical:* This is the application of only vertical collaboration to the prescribed case study. [55], [116], [117], [118], [119], [120], [121], [122], and [123]	The Hybrid approach was applied by most of the research cited in this category. The hybrid approach is a combination of proactive and reactive methods.	*Manufacturing*	The manufacturing sector comprises any companies that engage in the production of goods, services, and food business and was used as a case study in any of the cited publications. [140], [156], [157], [158], and [159]
	Vertical-Horizontal: This is a collaborative style that allows the combination of vertical and horizontal collaborations. Organizations collaborate vertically over identifies issues and horizontally through exchanges of resources. [118], [124], [125], [126] and [127]	Reactive method this style of collaboration is applied to resolve strong issues mitigating successful supply chain operations. Therefore, signifies recovery style and thus reactive method.	*Hospitality*	Hospitality businesses considered include hotels and tourist centers. [160], [161], [162], and [163]
Horizontal Collaboration	*Strictly Horizontal:* Introducing collaboration of two or more supply chain members to proffer a solution to a known disruptive event such as a pandemic. [116], [128], [129], [130], [131], [132], [133], [134], [135], [136], [137], [138], and [139]	The Hybrid approach was applied by most of the researchers cited in this category. The hybrid approach is a combination of proactive and reactive methods.	*Transportation*	Articles considered in this sub-category include logistics service delivery, transportation, disaster relief logistics, and warehouse management. [130], [164], [105], [165], [158], [87], [138], and [166]
	Horizontal-Vertical: This involves a combination of horizontal and vertical collaborations to address disruptive issues. [55], [128], [129], [140]	Reactive method: this style of collaboration is applied to resolve strong issues mitigating successful supply chain operations. Therefore, signifies recovery style and thus reactive method.	*Health*	The cases considered in this category include drug discovery and processing units, national and regional hospitals, and health research centers. [167] and [168]
Collaboration	Articles in this category review collaboration by offering several definitions, characteristics, and opening up general discussion on collaboration. [11], [141], [142], [143], [144], [145], [146], [147], [148], [149], [150], [151], [152], [79], [153], [154], [22], and [155]	Thematic and Systematic review.	*Others*	[11], [142], [49], [147], [148], [169], [74], [150], [170], [171], [172], [173], and [174]

TradeLens project [175] and [176]. The platform facilitates the secure sharing of real-time information among supply chain members and deals with supply chain risk management issues [177]. The application of information resources has been exemplified in the automation of the financial settlement process among supply chain members. Collaborative efforts on information available to supply chain members have enabled members to settle financial transactions in good time and at reduced costs [177]. This increases trust among members and reduces intangible risks such as fraud and unequal expertise.

In disruption, collaborative efforts on information resources are focused on the integration of IT systems. The integration allows organizations to construct collaborative platforms where activity data are shared to foster supply chain recovery. Examples of data shared are production levels and capacities; inventory levels and demand forecast; logistic and distribution management [178], [179].

The major drivers of information sharing and collaboration are trustworthy relationships and flexible capabilities; vertical and horizontal collaboration (see Table 8), and a decentralized structure of supply chain operations [103] and [109].

TABLE 8. Collaborative typology and information sharing.

Themes	Labour Resources	Material Resources	Information Resources
Types	As reported in the literature, labour resources examples include: • Skilled Labour • Semi-Skilled Labour • Unskilled Labour	i. Tangible resources: Examples of these types of resources are warehouses, tools, facilities, pieces of machinery, equipment, and logistics. ii. Intangible resources: examples of these resources as cited in the literature include reputations, interactions, and relationships.	Information resources as mentioned by the existing study are: i. Information technology ii. Communication technology iii. Soft materials
How do companies collaborate?	Companies collaborate on labour resources through the following ways: i. Hierarchical Exchange ii. Knowledge Transfer iii. Rescue Mission	Due to the nature of material resources organizations used up during supply chain disruption, existing studies have referenced the following resources: i. Rentals and exchange ii. Mixed resources	Organizations collaborate on information resources through i. Product traceability ii. Eliminate redundancy iii. Intermediation iv. Integration of IT system
Operational policies	Companies collaborate over units and departments in terms of disruption. For instance, companies collaborate in the production unit to correct demand and supply imbalances. Collaborate over logistic infrastructures and drivers. Disruptions in the inventory unit are addressed through the deployment of manpower.	Organizations formulated policies to coordinate the effective distribution of resources in a period of supply chain disruption. Some of the operational policies mentioned are: i. Sharing of supplier capacity; and ii. Sharing of the production facility	Part of the policies used to promote collaboration in supply chain operations during disruptions include: i. Trustworthy relationship framework; ii. Flexible capabilities; and iii. Structure decentralization to address the issue of Information hazards i.e. cybersecurity.

Precisely, information sharing of resources evolves beyond sharing of data and office information but the building of information platforms that perform needed functionalities to facilitate information sharing among members of the supply chain during disruptions. Table 8 contains collaborative typology and information sharing while Table 9 represents assessments of different strategies for sharing information resources. Information hazards such as cybersecurity and related security risks are essentials for the recovery of the supply chain and worth for members' collaboration to wage war against the occurrence of such risks [180]. In the paper, collaboration remains the focus but other information resource-sharing strategies were considered.

H. HOW SHOULD THESE TYPES OF RESOURCES BE PRIORITIZED?

Resource sharing along the supply chain network intends to integrate pooled resources contributed by organizations in the value chain. Submissions from existing studies show that sharing of resources by supply chain network members is arranged to address specific goals and objectives of members; identifying the appropriate resources and their combination; resource pooling and management. Therefore, recognizing resource sharing will offer theoretical and practical bedrock for resource identification and management.

In the aspect of setting desired goals and objectives, supply chain operation is facilitated with the movement of material resources, information resources, and financial resources to enhance the activities of organizations and business operation systems. In addition, studies have shown that effective coordination and integration of the movement are important to the management of the supply chain. For instance, Lepak et al. [181] emphasize the importance of logistic resource integration in achieving the goal of value creation and capture in organizations.

TABLE 9. Assessments of different strategies on sharing of information resources.

Sharing of Information Resources Collaboratively	Resource Sharing Strategies	Application Procedures	Risk Mitigation and Performance Outcomes	Relevant publications referenced
Collaboration	Sharing of information	Development of information platforms and IT connectivity for data and sharing of official information resources.	Facilitate the use of countermeasures and disruption signaling apparatus.	[180], [181], [182], [183], [184] and [185].
	Interaction and relationships	Information resources are shared through cooperation, integration, and efficient communication strategies set by supply chain members.	Motivational development and trust among supply chain members. The trust can either be formal or informal.	[186], [189], [194], [195], [187], [188], and [190].
Supply chain redesigning and re-engineering	SC network structure and design	The use of information resources to build supply chain networks for overcoming disruption challenges and resilience	Eradicating redundancy, and building of resilient SC network	[13], [76], [96], [191], and [192]
Dexterity	Increase SC visibility	Use of IT resources to develop transparency of the SC system	Threat detection, and promote the ability to offer immediate response to SC disruptions	[181], [182], [184], [191], [193], and [131].
Others	Construction of logistic capabilities	Promote efficient delivery, and cost-effective transactions across the chain processes	Transportation vulnerabilities and delay issues in supply chain operation	[37], [38], [76], [78], and [80].
	Tightening up security across SCs	Use of information resources such as blockchain and AI to the protection of activities across the supply chain.	Drastic fall in intrusion and stealing issues	[81], [82], [83], [108], [109], [115], and [117]

In the identification of resources, optimization of collaborative processes and strategies has enabled the organization to understand customers' needs and have enhanced supply chain configuration. Collaborative processes have been centered around two main categories such as horizontal, and vertical collaborations. In the work of Kumar et al [182], vertical collaborations have been researched based on the easy manner of application in the operational activities of organizations. However, little or no attention has been devoted to horizontal collaboration. Whereas the current COVID-19 pandemic had necessitated the need for the combination of efforts among organizations, which is a major theme of horizontal collaboration.

The management of resources concentrates on achieving an efficient combination of these resources. Studies have indicated that in a general disruption framework, labour resources are highly ranked among other resources. The combination of labour and material resources has been seen to be more effective to reduce the impact of disruptive events on organizational assets [183]. Within the confinement of COVID-19 effects, organizations should adopt more information resources, but better business outcomes can be attained through the combination of material and information resources. In this case, the labour resources should be less considered. Meanwhile, the impact of disruptions can be surmounted by using resource sharing among organizations. However, the sharing of these resources should be based on three resource management nests (Figure 7).

IV. DISCUSSION AND RESEARCH AGENDA

The benefits of resource sharing are determined by the abilities of organizations to make use of resources pooled for the achievement of common goals such as maximizing business profits or providing an efficient business operation system. Studies have highlighted that the benefits include fostering production and business outcomes; operating cost reduction; service quality improvement; and risk mitigation, respectively [59] and [184]. These buttresses the importance associated with advocating for a better understanding of the concept of collaborative resource sharing. In the advent of COVID-19, where business operations, profits, and costs were disrupted significantly, overall, organizational activities declined, and performances had contracted when compared to performances before the pandemic [70].

The review revealed that the vertical (internal) collaborative process is performance-inducement within the organization. It has been recognized as an efficient approach to addressing intra-organizational issues and documented as strategies to overcome production and distribution challenges within the supply chain, especially during catastrophic events [185]. Organizational outcomes were found to improve and the profit margin of most companies is revived after disruption when companies collaborate vertically. In the space of vertical collaboration, operational inefficiency and business costs have been reduced significantly, because organizations are able to collaborate vertically, even during disruptions [96]. Due to these contributions, the relevance of vertical collaboration within departments has improved business outcomes.

The patterns were observed from the articles in each of the clusters. As said earlier, three main patterns were observed and make up the analysis of the policy thrust. These patterns present the way collaborative resource sharing and classification of the resource types are been applied in the literature. These classifications are conducted based on the submissions of existing studies, as linked to the objectives of the research. Resources are classified into labour resources,

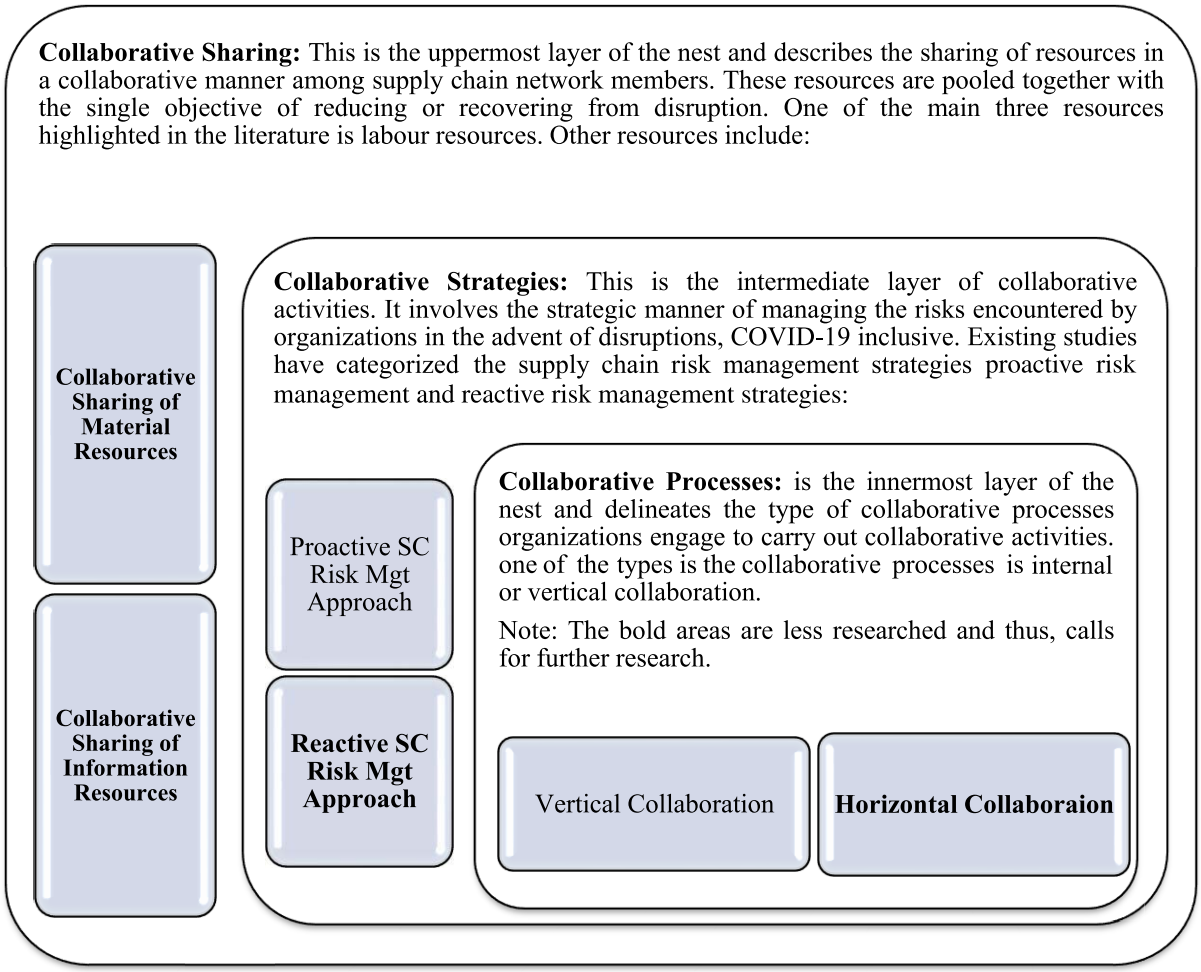

FIGURE 7. Nested relation of collaborative resources management.

material resources, and information resources. The prioritization follows the number of research articles that highlighted the importance of these resources, and the efficacy of the resources to ameliorate the impact of disruption on business operations, costs, and outcomes.

The paper prioritizes the resources as labour resources, material resources, and a combination of both resources in the occurrence of *general disruptive events*, whilst material resources and a combination of material and information resources are found to be essential in the wake of the *COVID-19 pandemic event*. Therefore, it is essential to grasp the knowledge of the submissions of studies on the strategic combination of an organization's resources to address disruptive events and alleviate the impact and consequences of the disruptive event.

A. RESEARCH AGENDA

Contributions of studies on issues of disruption in the supply chain have received greater attention before the current pandemic, and more importantly, after the advent of the COVID-19 disruption. The rising attention is because of the vulnerability and globalization of the supply chain [194]. The spread of the pandemic shows that there is an urgent need to increase interest in supply chain disruption, and it is not amazing to see rising submissions in this regard. After the systematic review, the following areas necessitate further research (Table10).

Studies have examined the internal arrangements for collaboration. Internal collaborative arrangements offered in the past include collaboration over employees, pieces of machinery, logistics and transportation routes, suppliers, and warehouses. The inter-department collaboration was widely researched. Conversely, little information is available on horizontal collaboration. The few studies examined had focused on production resources, for instance, Tesco and suppliers collaborate on logistics to mitigate the supply shortage of agricultural products. This is carried out through the introduction of a social network to promote collaboration. However, there is a lack of submissions in the literature on collaboration on classes of resources, and more so, horizontal type of collaboration.

Collaborative strategy is divided into two main paths namely proactive and reactive risk management strategies. The proactive strategy is set to prevent and mitigate the

TABLE 10. Future research outlines.

Research Area	Research Focus	Research Needs
Collaborative Processes	• Horizontal Collaboration: pooling of resources by two or more organizations to address disruptive issues.	• Application of horizontal collaboration in the manufacturing sector. • Fostering efficient production capacity of organizations in disruptions. • Mitigating disruptive risks in the Health sector.
Collaborative Strategies	• Reactive Risk Management Strategies: these strategies are used after the occurrence of disruptive activities such as collaboration and collaborative channels.	• Supply Chain collaboration – resources allocation and management. • Collaborative Strategies and effective production decision-making. • Towards efficient allocation of resources after disruptions in the manufacturing sector. • Prediction of disruptive events in Supply Chains through available information
Collaborative Sharing	• Collaborative Sharing of labour resources • Collaborative Sharing of material resources • Collaborative Sharing of information resources	• Optimized the structural design of the sectoral supply chain through automation. • Improving product distribution efficiency within the supply chain through digitalization and information sharing. • How does sharing of an organization's resources promote supply chain resilience? • How are an organization's resource types pooled to foster supply chain efficiency during disruptions?

occurrence of disruptive events, while the reactive strategy ensures faster recovery from the impact of disruption. It is observed that collaboration among supply chain members is often temporary rather than permanent since it is a strategy that is mainly applied to foster the recovery of the supply chain. Sharing of resources is also temporary and management of resources is done by the organization affected by the disruption. However, central administrative control of collaborated resources is important for the effective coordination and distribution of the resources to engage recovery processes. For instance, in Riken and Nissan's cases, the recovery processes were coordinated differently.

In collaborative sharing, as documented in the literature, resources are shared based on three main features namely *adaptability, mobility, and available capacity*. With regards to labour resources, the adaptability feature is clear to be identified. For example, in Aisin's recovery plan, the use of employees of their suppliers and the ability of customers to adapt promptly to changes in activities apparently explained the adaptability feature. Mobilizing resources in the case of Renesas, where over 2500 engineers were sourced from other organizations to address recovery issue show the importance of available capacity, which is a feature of shared resources.

These three features of resources are highly important for the implementation of the collaborative sharing of resources. Future research should focus on sharing labour, materials, and information resources collaboratively, but these resources must consider the characteristics of the resources to be shared.

Based on the discussions, the submissions in the literature have shown that the three areas of research are important to explain the collaborative sharing of resources and disruption recoveries, and major themes of concentration were identified. The research needs were also highlighted in Table 10.

V. CONCLUSION AND RECOMMENDATIONS

This systematic literature review investigated the application of one of the reactive methods of supply chain risk management namely collaborative resource sharing to manage (reduction and recovery) the impact of disruptive events on the supply chain. This article sets forth the need to present research on the collaborative sharing of resources, how supply chain partners can collaborate and what type of resources the organizations can consider during collaboration. This review has exposed that substantial research existed on vertical collaboration, however, there is an absence of research on horizontal collaboration. Based on the screened sample of 195 articles, this paper has identified the types of resources available to the organization to explore as during and post-disruption recovery strategies and their classifications. These resources are broadly classified into three groups by existing studies namely labour resources, material resources, and information resources, respectively.

The findings show that majority of the articles sampled are supported material resources and few articles considered sharing of information. More so, articles on supply chain collaboration and collaboration are well documented, nonetheless, collaborative resource-sharing articles are very limited. Again, categorical analysis reveals that the application of collaborative resource sharing in the health sector was not given adequate attention. Finally, within the information resource sharing collaborative exercise, implementation of collaborative planning, forecasting, and replenishment are currently at their early stages.

For COVID-19-related disruptions, organizations need to collaborate on material and information resources for effective and prompt recovery of supply chain activities. It is also essential to consider collaboration on skilled labour resources to bridge the resource interaction gaps between the materials and information resources, respectively. Hence, collaboration on the three resources is highly essential for the efficient recovery of supply chains.

Conclusively, the role of collaborative resource sharing has been established to be essential for mitigating the impact of disruptive supply chain events. Hence, there is a need for an empirical examination of collaborative resource-sharing strategies as a means to improve resilience to major disruption events. More importantly, the need to provide collaborative design and the application of design in the health sector should be on the agenda for future research related to improving the ability to react to future health crises.

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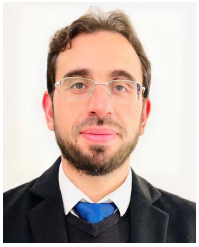

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