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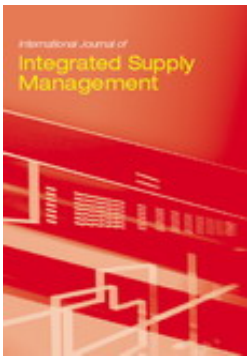

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Supply chain collaboration in times of crises

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Abstract: This article aims to provide a systematic and comprehensive summary of the current state of research on the young yet developing field of supply chain collaboration in times of crises. A systematic literature review identifies 45 articles, which are described, analysed, and classified. Based on 45 articles, the state of research is summarised, and three research areas are identified. The main categories derived include: 'strategic guidance of collaboration network', 'structure and operational management of collaboration', and 'risk assessment and management in the collaborative network'. These are of central relevance for firms in a collaborative supply chain in times of crises. Managerial insights regarding the design and alignment of collaborative supply networks are included in the article as well. The core concern is identifying the basic requirements for collaborations in supply chains during periods of crises. The main criteria for success are extracted and classified, based on a systematic literature review.

Keywords: supplier management; collaboration; strategy; risk management; crises; risks; disruption.

Reference to this paper should be made as follows: Allmann, M. and Gansterer, M. (2024) 'Supply chain collaboration in times of crises', *Int. J. Integrated Supply Management*, Vol. 17, No. 1, pp.32–72.

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1 Introduction

Due to potentially abrupt and unpredictable changes caused by crises, companies need to continuously adapt their business processes to the supply chain workflow (Caputo and Mininno, 1996). Crises, in this context, refer to events that have a large negative impact on firms involved in the supply chain networks (supply chain includes the planning, execution, and control of all operations related to the flow of materials, finances, and information) (Ellram, 1995). Consequently, supply chain processes involve multi-stage, upstream, and downstream connections among various integrated firms, involved in value creation, forming a network, beginning with raw material acquisition, through the value-adding stages, to the end consumer (Caputo and Mininno, 1996).

Increasing complexity and diversity in the business environment are forcing companies across industries to face new challenges (Ellram, 1995). Supply chain management concepts need to be adapted to these new requirements, in order to control and manage developments in this core functional area. Special emphasis needs to be laid on configuration, as well as on the later steps of planning and execution, throughout the operationally provided designing of the collaborative network (Ellram, 1995).

Volatility is a challenge to efficiently designed logistics networks, and becomes increasingly apparent in times of crises. Delays, interruptions, and delivery restrictions have to be simultaneously managed within the supply network, so that the economic flow of goods and services can be resumed as usual (Blome and Schoenherr, 2011). The ongoing COVID-19 crisis not only affects various industries but also varies markets with different end-customer layers. This means that, existing logistic concepts have to be reworked and adapted to the situation, so that they meet the rapidly changing requirements (Blome and Schoenherr, 2011). Efficient logistics create sustainable competitive advantages and contribute to a firm's success. This requires a change of perspective, with the focus no longer being on the next company in the value chain; rather, all efforts need to be aimed toward satisfying the requirements of the end customer. However, a whole new set of skills are essential to overcome this challenge (Ellram, 1995).

1.1 Previous literature reviews

This sub-section and the further one refers to the existing literature in the field, and points out the added value of our work in comparison with the existing ones. The current literature review focus on the topic of collaboration during crises with special reference to supply chains.

The literature review provided by Sawyerr and Harrison (2019) identifies the prevalent elements of supply chain resilience found in the literature, compare it to the characteristics of high reliability organisations (human resource management, avoidance, redundancy, collaboration, culture, agility and flexibility) and derive useful learnings to enhance supply chain resilience. Two systematic literature reviews were performed, one on supply chain resilience (107 studies) and the other on high reliability organisations (18 studies). The time period reviewed for supply chain resilience is between 1997 and 2017 and for high reliability organisations between 1987 and 2017. The authors found that resilience is particularly essential in supply chains, as the frequency of disasters is increasing globally. Furthermore, in times of crisis, flexible decision-making structures are needed to ensure a high level of reliability in the collaboration between supply chain

network partners. The main focus is on high reliability organisations, which have the ability to avoid interruptions and operate at a high security standard. This review seeks to identify and present key characteristics from the literature on supply chain resilience and high reliability theory.

The literature review presented by Fischer-Preßler et al. (2020) examines the potential use of information technology in supply chain risk management. The review is limited to a 15-year period (2004–2018). A total of 55 articles were examined. The authors mention that information technology offers potential in terms of support for supply chain risk management. Information technology also provides the basis for the identification, analysis, and monitoring of risk factors, and is a starting point for more profound investigations. This paper identified the current knowledge on avoiding and managing supply chain risks and disruptions using information technology is insufficient. Therefore, the authors provided an overview of starting points for future research in this area. It highlights perspectives and research possibilities for information technology support in addressing disruption risks for both information and physical supply chain streams.

The last identified literature review published by Montoya-Torres and Ortiz-Vargas (2014) examine the relevant literature issuing the impact of collaboration and information sharing in supply chains. The assessment period for the study was set to the period between 2000 and 2012. This corresponds to a time horizon of 13 years for the analysis. At the end, 120 references were selected for further study. These authors identified information exchange and coordination between supply chains operators are an effective strategy for increasing the overall performance of a supply chain. Moreover, depending on the industry, the content of information shared varies. The willingness to share information depends on the type of relationship that prevails in the supply chain. This study aims to indicate how information-sharing patterns are adapted to the ways in which the collaborative relationship is managed.

Characteristics of high reliability organisations provide insights into which aspects are relevant and where the focus of attention might be in terms of supply chain resilience. The second and third literature review also provides perspective on identifying elements that are relevant for supply chain resilience. Addressed here are the specific use of information technology and the need to share information along the partnerships. The research gap that appears relates to the practical applicability and feasibility for firms and collaborations to strengthen their network. In more detail, it is to determine how the supply chain network structure can be designed/aligned and how diverse firms might approach it to create a resilient and robust collaborative network. This literature review responds to this described lack of research.

1.2 Positioning of current literature review

The added value of our study is the structuring of the research field in relation to crisis and the provision of main finding categories

1 Strategic guidance of collaboration network.
2 Structural and operational management of collaboration.
3 Risk assessment and management in the collaborative network) as well as their respective sub-topic areas

1.1 The prioritisation of the core strategic elements and strategy adjustment.
1.2 Defining goals and transforming the strategy into operational measures.
1.3 Cultural development and consolidation.
1.4 The creation and use of know-how capabilities.
1.5 The incentives and (contractual) binding of participants as well as the power imbalance in the network.
2.1 Trust in the collaboration and its participants.
2.2 Commitment and contribution in the collaboration.
2.3 The deployment of operational resources.
2.4 The exchange of communication and information in the collaboration.
2.5 The implementation and integration of operational systems or processes.
3.1 Risk prevention and risk management measures.
3.2 Knowledge and information about potential risks in the operating business field.
3.3 The evaluation and assessment as well as the management of known risks) that ought to be addressed for supply chain network design in order to increase resilience and robustness.

In addition, the main finding categories and also in detail the sub-topic areas are discussed in comparison with the information on network extension, firm size and industry segment derived from the article base in order to generate design approaches for individual networks. Further in this context we analysed the development of the research field, the research methods and methodology applied as well as the relation to the published journals. The considered articles to analyse are 45 papers from a timeslot between 2007 and 2020.

This review is structured as follows: First, there is a brief discussion of the concept of collaboration in supply chains during crises. This is followed by the research methodology used for the search and the framework for analysing and classifying the contributions. Next, the main findings about the research topic are presented. Afterwards, the main findings are discussed coherently and the context for designing robust and resilient supply chains is presented. This serves as a starting point for diverse decision-making levels in supply chains in terms of operational and strategic alignment of the supply network. Finally, the linking of research opportunities and the summary are presented.

2 Theoretical framework for collaboration in times of crises

Forms of supply chain collaborations can range from a simple exchange of information to integrated firm processes, wherein collaborating firms merge their workflows, align their targets, and even appear as one unit on the market (Leathard, 2003). Therefore, the next step involves identifying the criteria for determining possible forms of collaboration.

2.1 Conceptualising collaboration in supply chains

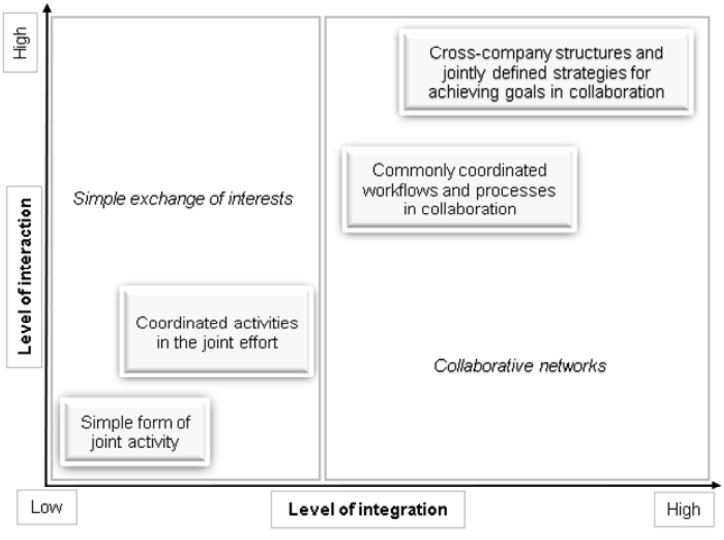
We define collaboration in supply chains as the establishment and expansion of relationships between firms that combine shared competencies and processes, in order to increase the flexibility and agility of participating firms, share risks, and better manage unforeseen disruptions (Nemeh and Agi, 2019; Yuan et al., 2020). These networks focus on the idea of community and cohesion, which is reflected in daily workflows and the long-term shared alignment, as well as in the creation of mechanisms to mitigate negative impact on the community (Wang and Wei, 2007).

The above-mentioned approach is characterised by the sharing of supply chain assets for value creation, in order to gain mutual benefits for the participants involved (Nemeh and Agi, 2019). To achieve defined objectives, which could not be fulfilled independently, collaborations mostly among legally and economically independent firms are set up. Such collaborations help to share information and resources as well as to create knowledge through the transfer of know-how (Prakash and Deshmukh, 2010). Moreover, coalitions empower firms to face internal and external challenges by increasing their common competitiveness (Prakash and Deshmukh, 2010).

The definition of collaboration reflects the commonly defined and jointly designed performance interdependencies. It also denotes the deep interaction and integration among participants, which are required for the execution of the planned activities.

Figure 1 shows the level of interaction on the vertical axis and the level of integration on the horizontal axis. We examine the link between both dimensions, to arrive at a classification of various working relationships. In the left box simple exchange of interests is indicated, and on the right box, collaborative networks can be seen.

Figure 1 The extent of collaboration



Source: Wang and Wei (2007) and Yuan et al. (2020)

The level of interaction varies from 'low', which can be linked to simple interactions of data exchange (Wang and Wei, 2007), to 'high', which can be associated with intensive interactions deeply embedded in performance-specific and/or service-related business activities. Interactions refer to communication or direct involvement with participating persons within the network or within the commonly used system/process tasks. Here, the frequency varies from low to high (Yuan et al., 2020). The level of integration varies from 'low', which can be connected to independent and unconnected relationship with no or hardly any procedural linkages between firms, to 'high', linked to combine processes that are aligned across multiple firms. Integration determines the extent of involvement in the network; the frequency varies from low to high (Wang and Wei, 2007).

Table 1 Classification of collaborations

Classification characteristics	*Simple form of joint activity*	*Coordinated activities in the joint effort*	*Commonly coordinated workflows and processes in collaboration*	*Cross-company structures and jointly defined strategies for achieving goals in collaboration*
Overall achieved goal	Maximising the benefits for the members involved	Recognising the importance of common achievements; the focus is nevertheless on maximising the benefit of each individual	Increasing division of labour in the domain of services and promoting collective activities – Collaboration now prevails over individual benefits	Goals are to be defined jointly, considering the resources contributed
Information exchange pattern	Primarily includes information exchange for the benefit of the participants	Communication and information sharing occur more regularly and are aligned with stakeholders' activities	With regard to inter-company processes, the information flow is coordinated and aligned	Information exchange is assigned highest value – The various systems and software used are compatible
Strength of expression in terms of interaction and integration	In both cases low	In both cases low to medium	In both cases medium to high	In both cases high
Reference to a contractual obligation	Mainly flexible agreement without legal or contractual obligations	A comprehensive contractual regulation is not provided, legal obligations occur	Cross-company collaboration is an important part of service provision and is contractually secured	The collaboration is contractually regulated
Exemplary practical reference of the type	Sharing of best practices and know-how	Starting to set up overall commonly used processes	Target-oriented project or research activity	Coordinated tasks, research on new technologies and their implementation

Therefore, up to a certain point, the work relationship among firms is simply an exchange of interests, which cannot be referred to as collaboration. When the level of interactions and integration increases, it is reasonable to consider it as collaboration, because it involves inter-company activities that become firmly anchored in internal workflows (Yuan et al., 2020). In the literature, we find various classifications of the ways in which participants can work together. Relevant examples can be found in the article by Yuan et al. (2020) or by Gallié and Roux (2010). This literature review focuses on the core groups mentioned in Figure 1. Their detailed descriptions can be found in Table 1.

In the following section, collaborations are investigated in the context of crises.

2.1.1 Determination of crises in the context of supply chain collaboration

Disruptions in the supply chain vary in their impact. Such disruptions range from a negligible effect due to a minor, predictable impact on the organisation, to serious and lasting repercussions that are difficult to identify in advance and affect the supply chain as a whole. Disruptions also vary in terms of the frequency of occurrence. Disruptions with a slight impact on the network occur more frequently than those having a major impact. The task is to identify when disruptions represent crises for the network. For this purpose, various disruptions have been listed in Table 2, organised according to their impact and the probability of the network being affected.

Table 2 Different types of disruptions

Different disruption types	*Detailed description*
Level 1 disruptions (short-term interruptions)	The level of influence on the network of an event and its impact on collaboration is rather low and consistently manageable (Birkie and Trucco, 2020). Up to several partners in the network are affected, although, with the additional use of resources, it can be ensured that the objectives are achieved (Revilla and Saenz, 2017).
Individual situation-dependent decision	The relevant events have a medium to high level of influence on the network. Moreover, the effects are noticeable to most of the participants. Restrictions in the operative process of collaboration are revealed during the event, and hence, the planned approach for the achievement of objectives requires adaptation (Bealt et al., 2016). Close collaboration and transparency are required within the network to analyse the situation inside an appropriate time horizon and to initiate suitable counter-measures (Revilla and Saenz, 2017).
Level 2 disruptions (crises)	These disruptions are caused by crises and affect all participants in the network. Their effects on collaboration have far-reaching consequences (Scholten et al., 2019). Not only operational activities and processes are affected, but also the long-term planning and strategic direction of the parties in the network (Revilla and Saenz, 2017). It is essential to prepare the supply chain for such crises in advance – with special focus on the network design. Further, the alignment of the supply chain has to be coordinated, in accordance with the type of collaboration. (Birkie and Trucco, 2020).

Based on the above-mentioned considerations, we define crises as disruptions with a high impact on participants in the network and a high probability of being affected. These

serious effects no longer affect individual participants, but rather the entire network, which cannot longer operate as usual to carry out its regular activities (Bealt et al., 2016). The time frame and result of the overall damage cannot be determined during the crises; it can only be ascertained after the crises have ended (Scholten et al., 2019).

2.1.2 Characterisation of crises

Crises can be characterised based on various attributes. The impact on participants and the probability of the network being affected are constitutive characteristics, whereas the unpredictability, ambiguity, time pressure, and obligation to decide, as well as the existential threat are descriptive attributes of crises (De Sousa Jabbour et al., 2020). The detailed descriptions of crises can be found in Table 3.

Table 3 Attributes of crises

Attributes of crises	*Detailed description*
Unpredictability	Crises are unexpected situations caused by various events inside or outside the organisation (e.g. Scholten et al., 2019). This forms the basic framework of organisational expectations, and leads to the design of a desired order based on future projections (e.g. De Sousa Jabbour et al., 2020).
Ambiguity	In crises, the origins and causal correlations are not clearly identifiable. Due to the arbitrariness of such events, it is not feasible to predict crises, and they are only conditionally explainable in retrospect (e.g. Bealt et al., 2016).
Time pressure and the obligation to decide	Crises occur in a limited time-frame, allowing the affected parties only a short time to decide and initiate corrective actions. Crises have an inherent tendency to escalate, thereby shortening the available reaction time even further (e.g. Bealt et al., 2016).
Existence-threatening development	Crises occur unexpectedly. Moreover, they entail far-reaching consequences, which threaten the organisation and its network (e.g. De Sousa Jabbour et al., 2020).

2.1.3 Consequences of crises for supply chain participants

The challenges to be addressed include sudden and irreplaceable supply bottlenecks on the part of subcontractors, rapidly changing quantities of various products, the lack of machine capacity to meet the demand for certain products, as well the irregular delivery of goods (Bealt et al., 2016). Taking an even more careful look at the supply relationship, it is noticeable that the inter-relationships and structures are only partially comprehensible. During crises, forecasts end up being less precise, and the continuity and reliability of data decreases (Scholten et al., 2019). The escalation of the recent worldwide pandemic has had considerable implications on the international division of labour. In particular, the supply of foreign advance payments is no longer guaranteed. The absence of workers and the closure of production facilities have led to production losses (De Sousa Jabbour et al., 2020). During crises, companies ought to adjust their business models and rethink global supply chains, in order to reduce dependence on global production networks (Scholten et al., 2019).

3 Methodology

In order to address the supposed weaknesses of a narrative review (Tranfield et al., 2003; Wong et al., 2012), in this paper, a systematic, evidence-based approach was selected. Following Fink (1998), from a methodological aspect, a literature review is a systematic, explicit, and reproducible approach to identifying, evaluating, and interpreting the available documentary evidence. The literature review methodology adopted in this paper follows a five-stage classification approach according to Wong et al. (2012):

Step 1 Formulate the research objective and question: A clear research objective and question are essential to determine the focus and direction of any research. This article focuses on the issue of collaboration in supply chains in times of crises, and identifies main finding categories as well as sub-topic areas for network designing approaches in order to deal with potential threats to ensure the resilience and robustness of the collaborative network. This integrative approach serves as a triggering point for decision-making in the management of a firm, which adopts a resilient and robust collaboration design and forces the integration of potential partners. The core objective of this paper is to identify the basic requirements for collaborations in supply chains during crises referring to various sizes of firms in the logistics network and their configuration with respect to the network design. These relate to how the design of supply chain activities can be adapted, and tactical/operational activities can be aligned, in order to effectively strengthen the supply network. The research question to be addressed in this literature review is: What is the current state of academic research on the impact of crises in supply chains and can basic requirements/key areas be identified for different firm sizes and network configurations in order to increase the overall resilience and robustness of supply chain networks?

Step 2 Locating studies: Two decisions need to be considered in this stage: The search source used and the search criteria applied. It was decided to use a variety of databases (Science Direct, Emerald Insight and Web of Science) in order to locate relevant articles. We used the following configuration and query strings per database: Science Direct [(Supply Chain OR Supply Chain Management) AND (Cooperation OR Collaboration) AND (Crisis OR Risk OR Disruption OR Disaster OR Uncertainty))], Emerald Insight [Abstract: 'Supply Chain OR Supply Chain Management' AND (Cooperation OR Collaboration) AND (Crisis OR Risk OR Disruption OR Disaster OR Uncertainty)] and Web of Science [Topic: (Supply Chain OR Supply Chain Management) AND all fields: (Cooperation OR Collaboration) AND all fields: (Crisis OR Risk OR Disruption OR Disaster OR Uncertainty) – Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A and HCI, ESCI.]. Moreover, we also examined cited articles found in the previous literature reviews. We also consulted the bibliography of relevant articles to further identify pertinent articles. With these actions we were able to identify additional 74 articles. In a last step we searched the Social Sciences Citation Index (SSCI) for each article appropriate for inclusion. A total of 2024 articles were obtained at the first stage of the search process. After removal of duplicates 1,831 articles left. The exclusion process is illustrated in Prisma Flowchart mentioned in Figure 2.

Step 3 Study selection and evaluation: To select and evaluate studies appropriately, we followed the Prisma Flowchart guidelines, as shown in Figure 2. The Prisma Flowchart diagram has four steps: identification, screening, eligibility and included, and we followed them in the article selection. Within the identification stage, articles were required to meet the following criteria:

1 Articles had to refer to the research area (supply chain collaboration in times of crisis). The relevance of content was ensured by selecting articles containing at least one search attribute in their title or abstract.
2 Only articles written in the English language were considered.
3 Articles needed to be published in peer-reviewed journals or conference proceedings.

The screening stage contains a check of the abstracts of remaining articles, in order to eliminate articles unrelated to the research interest. Exclusion criteria at this stage are:

1 Type of publication (document type, experimental protocol, editorial material and proceeding paper is not included).
2 Missing link to define the research field (article objective mismatch and no supply chain collaboration and/or crisis relation).
3 Research field in article (non-business focus as clinical, biological, psychological relation).
4 Research focus of article (non-business focus as humanitarian supply chains).

The eligibility stage refers to articles that are potentially included in the literature review. The complete body of the article was reviewed to determine whether it should be included or excluded from the literature review. Further, exclusion criteria in this section included:

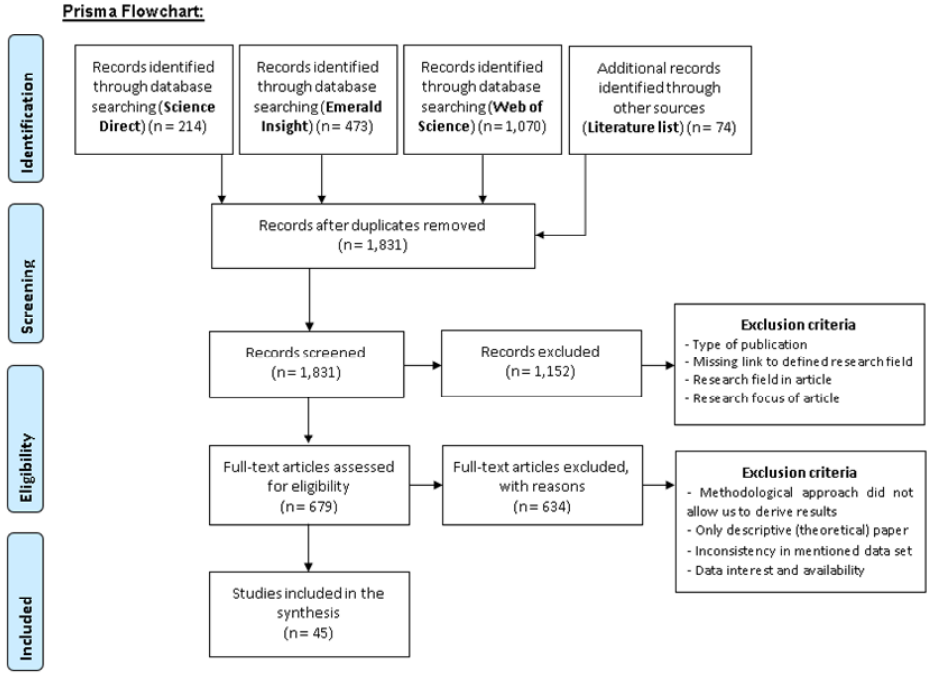
1 Methodological approach, which did not allow us to derive results (only empirical articles were considered here).
2 Only descriptive (theoretical) articles.
3 Inconsistency in mentioned data sets.
4 Data interest and availability (i.e., article lacking sufficient information linked to our research area or no comparable outcome measures).

In the last stage, articles included in the literature review were mentioned. By following the above-described steps, 45 articles were selected for further investigation.

Step 4 Analysis and synthesis: In this step, the shortlisted research articles were analysed in more detail to examine how the research has evolved over the time horizon. All included articles were analysed with regard to the applied sample data, year of publication, journal published, research questions, research objectives, scientific approach (methodology), and summarised findings. The articles were further analysed via citation network analysis, performed using CitNetExplorer version 1.0.0. This software helps visualise the connections among the existing literature and thus allows detecting possible core publications within the network.

Step 5 Reporting and usage of results: This literature review is the first formal presentation of the results to the scientific audience. In the following sections of this document, these results will be provided and suggestions for continued research have been formulated.

Figure 2 Illustration of prisma flowchart (see online version for colours)



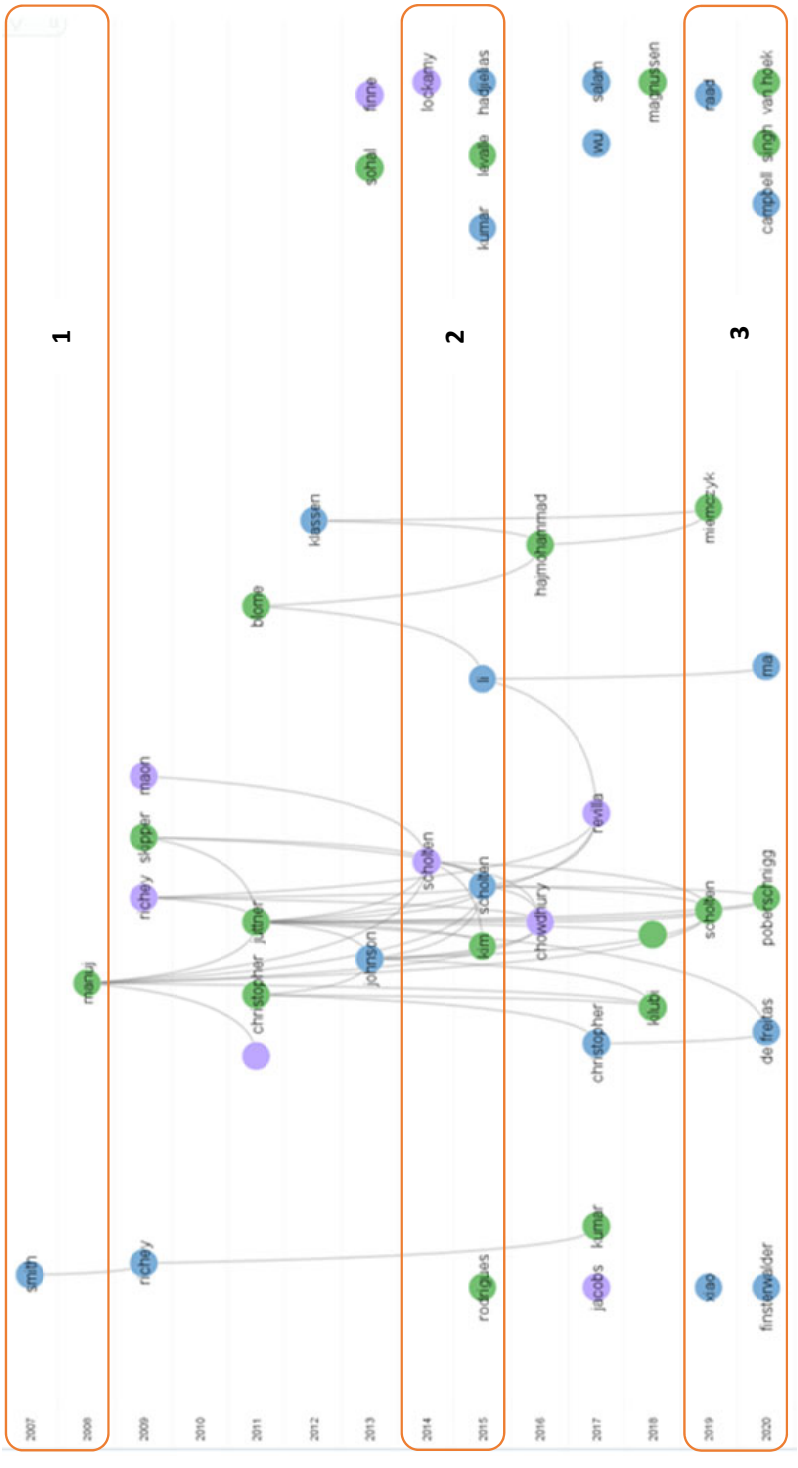
4 Findings

In this section, we present findings related to citations, research field, methods, and sample data.

4.1 Citation network analysis and the development of the research field

We first present the results of the citation network analysis, shown in Figure 3. At the centre of the citation network, various clusters can be seen, which have developed over time. These relationships are very profound in some cases, and central publications are identifiable. These articles linked among each other compose the core literature in this research field. On the right side, individual articles are plotted, which do not have any connection to other articles. On the left side, single articles are represented with a few connections.

Figure 3 Illustration of citation network (see online version for colours)



The aim is to link identified publications, over time, to major crises with global impact (chronologically numbered and displayed in boxes with orange borders within Figure 3) in order to describe the development of the research field.

1 Between 2007 and 2008, the research field developed. At this time, a financial crisis occurred, globally impacting the financial sector and beyond.

2 There was a larger accumulation of articles published between 2014 and 2015. During this period, the sovereign debt crisis in Europe, which affected Greece in particular, the Russian economic crisis, and the subsequent annexation of Crimea by Russia may be mentioned.

3 Finally, there is also an excessive number of articles published between 2019 and 2020, which may be attributed to the COVID-19 pandemic. Colour coding has been applied to distinguish the derived main finding categories, which are described in greater detail in this section.

In addition, we analysed the number of articles by year of publication. For statistical analysis, a total of three five-year clusters were formed, and the 45 articles were classified in terms of publication date. The first cluster (2006–2010) includes six articles (13%), the second cluster (2011–2015) contains 16 articles (36%) and the third cluster (2016–2020) includes 23 articles (51%). The second and third cluster cover 39 articles (87%); these articles were published during the last ten years, with a majority being published during the last five years.

The next step in the evaluation of the development of the research field was to examine the relationship between the citation network and the derived main finding categories. Three different colours were used to indicate the distribution of the citation network. Green represents literature that has been linked to the first main finding category (strategic guidance of collaboration network). Blue is associated with the second main finding category (structural and operational management of collaboration), and purple reflects the literature that can be allocated to the third main finding category (risk assessment and management in the collaborative network). The three main categories are consistently distributed differently, in terms of the frequency of the citations. Nevertheless, in the central area of the citation analysis, all three main finding categories are represented.

4.2 Investigated research methods and methodology applied

Our study found that the following five research methods were the most prevalent among the 45 identified articles: interviews/surveys, case studies, experiments, observational trials, and ethnography. The category of interviews/surveys included 15 articles (33%). About 13 articles (29%) adopted the research method of case studies. Seven articles (16%) were linked with category of experiments. The research method of observational trials was employed in five articles (11%). Finally, five articles (11%) used ethnography. The three most frequently used methods (interviews/surveys, case studies and experiments) are reflected in 35 articles (78%). This implies that almost every fourth article out of five uses one of these methods to investigate this research topic.

The research methodology used, classified into qualitative and quantitative approaches (mentioned in the Appendix), is equally distributed across the board. Of the 45 articles selected, 23 articles (51%) employed quantitative analysis, whereas 22 articles

(49%) used qualitative analysis. A step further in the analysis, in comparison with the main finding categories, reveals quite a different picture. The main finding category one show that six articles (32%) was investigated using a qualitative approach and 13 articles (68%) were examined using a quantitative approach. The strategic section in supply chains therefore tend to be investigated more likely with quantitative approaches. In the second main finding category, 11 articles (65%) are qualitatively and six articles (35%) are quantitatively analysed. In the operational environment qualitative approaches are the main used techniques. In the third main finding category five articles (56%) are qualitatively and four articles (44%) are quantitative analysed. The area of risk and risk management in supply chains is therefore examined in more or less equal measure in terms of both qualitative and quantitative aspects.

The qualitative and quantitative methodology approach is equally distributed with respect to the publication period. No concentration in a particular time cluster can be identified.

4.3 Analysis of publishing journals involved

The next step involved the linking of the selected 45 articles to the top five journals wherein they were published. Thirteen articles (29%) were published in *Supply Chain Management: An International Journal*. The *International Journal of Physical Distribution & Logistics Management* featured six articles (13%), the *International Journal of Production Economics* printed four articles (9%), and the *International Journal of Operations & Production Management* and *Journal of Operations Management* published three articles (7%) each. The remaining 16 articles (35%) were published in single individual journals.

The three most frequently identified journals cover 23 articles (51%), which equal more than half of the total identified articles. Referring to the journal *Supply Chain Management: An International Journal*, articles published here mainly covered a time period between second and third clusters (2011–2015; 2016–2020). Six articles were examined for each cluster. The research field is continuously and evenly intensively studied. The published articles are equally distributed over the publication period within the clusters. In the journal *International Journal of Physical Distribution & Logistics Management*, three of six articles were published in the first cluster (2006–2010). The last article was published in 2017. The publication interest is observed rather in the emergence of the research field and less in the temporally younger development area. The *International Journal of Production Economics* published three of four articles in the period of the second cluster. The fourth article was published in 2020. This journal tends to address the research field at an already developed stage and the interest in publishing remains until today.

A closer look at the publications in the top three journals reveals that *Supply Chain Management: An International Journal* mainly publishes qualitative analysed articles 10 of 13 (77%). Seven out of 13 articles (54%) use the research method case study and four out of 13 articles (31%) use interviews/surveys. The remaining two articles are equally distributed along the remaining research methods. The *International Journal of Physical Distribution and Logistics Management* published five out of six qualitative articles (83%). The five clustered research methods are distributed equally. Similarly, in the *International Journal of Production Economics*, all four articles were analysed qualitatively and the used research methods are distributed equally.

If we compare the journals with the main finding categories, we find that the journal *Supply Chain Management: An International Journal* is almost equally distributed in the three main finding categories. Five articles (38%) can be assigned to main finding category one (strategic guidance of collaboration network), another five articles (38%) to main finding category two (structure and operational management of collaboration) and three articles (23%) to main finding category three (risk assessment and management in the collaborative network). With reference to the journal *International Journal of Physical Distribution & Logistics Management*, five articles (83%) were examined in the first main finding category and a further article (17%) in the second main finding category. It can be noted that the journal mainly covers strategic aspects and publishes less in the direction of operational guidance of the supply chain and risk management. The *International Journal of Production Economics* published two articles (50%) in each of the first and second main finding category. Strategic and operational aspects are published here in equal measure; it seems that risk and its management are not the primary topics for this journal related to the research discipline.

4.4 Derivation of key results and formation of main finding categories

This paragraph contains the analysing of findings from the 45 articles. First, the findings were read in their entirety, so that the range of diverse results could be clarified and classified. Second, the core findings of each research study were combined to form a statement. Subsequently, the overall statements were combined into homogenous clusters. These sub-topic areas (clusters of homogeneous groups) then formed the main finding category. The overall statements related to the sub-topic areas contain a running number at the beginning, which indicates a reference to the respective article.

An overview of the articles can be found in the Appendix. Each overall statement was assigned to one or two different sub-topic areas, which were then designated to the respective main finding category. Multiple connections among the overall statements for the articles were established only within the respective main finding category and not across the main finding categories. Each published article is therefore assigned to exactly one main finding category, and there are 45 mentions in total within the three main finding categories. This amount also equals the identified article basis.

The three main finding categories are as follows:

1 *Strategic guidance of collaboration network:* This category covers internal and external focus areas such as the strategic focus and derivation of operational measures, culture, the processing of know-how, and the incentivisation of all participants in the network.

2 *Structural and operational management of collaboration:* Here operational focus areas such as trust, cohesion or commitment, the efficient use of existing resources, and the systematic exchange of data as well as the implementation and integration of operational systems are included.

3 *Risk assessment and management in the collaborative network:* This category covers topics related to risk identification, classification, and categorisation, and the derivation of suitable measures to maintain the network.

The main finding categories including the sub-topic areas, which contain the relevant article findings, are presented in Table 4.

Table 4 Summary of the derived main finding categories as well as the associated subcategories, which contain the relevant findings of the 45 identified articles

Main finding categories	*1. Strategic guidance of collaboration network*	*2. Structural and operational management of collaboration*	*3. Risk assessment and management in the collaborative network*
Sub-topic areas including linked overall statements from article findings	*1.1: The prioritisation of the core strategic elements and strategy adjustment* (2.) It is important to jointly develop a suitable risk management strategy, which can then be implemented across the network. (4.) Fundamental management orientations, which are reflected in the network strategy, promote disaster and crisis preparedness and management in the supply chain. (7.) Flexibility improves the ability to mitigate risks in the event of a supply chain disruption. (8.) To develop structural flexibility to meet the challenge of increasing turbulence, it is essential to understand the sources of variability and build simple models that can assist in mitigating this variability. Supply chain flexibility requirements are to be embedded in the supply chain strategy. (24.) Disruption has a negative impact on the financial performance of individual firms in the supply chain. Liquidity and flexibility in terms of cashflow are therefore of particular relevance. (27.) Firms aim to strategically build their capabilities to achieve greater resilience, robustness, agility, collaborative capacity, and risk awareness. (31.) Firms that adopt an inter-organisational orientation experience the lowest levels of supply chain disruption. In contrast, strategies that focus only on the control of internal operations are not sufficiently robust to stop the effect of disruption at the supply chain level. (38.) Social supply chain strategies have a positive impact on environmental and cost performance when mediated through risk assessment practices.	*2.1: Trust in the collaboration and its participants* (11.) The duration of relationship and the trust of suppliers can enhance the effectiveness of risk information sharing. (12.) Collaboration and willingness to share data is relevant in terms of identifying supply chain risks. However, this sensitive and simultaneously shared information carries its own risk for the collaboration. (25.) Trust between partners is a pre-requisite for horizontal collaboration in a jointly operating supply chain. (26.) Critical success factors in inter-organisational collaboration are trust and a sense of responsibility. Trust facilitates the creation and sustainability of cooperative relationships. It is also important in motivating companies to work together. (30.) Trust, developed through an ongoing relationship that is shaped over time, has a significant impact on supply chain collaboration and operational performance. (45.) Top management support and trust are the essential factors for supply chain collaboration.	*3.1: Risk prevention and risk management measures* (1.) The supply chain risk and knowledge management appear to improve supply chain resilience by increasing supply chain flexibility, visibility, speed, and collaboration. (5.) Developing an integrated framework for supply chain resilience involves the interaction of disaster management processes and capabilities, as well as the processing of appropriate measures to prevent crises from emerging. (14.) The most important tasks of disaster management are prevention and planning as well as responding with accurate measures and recovering. (15.) Important for risk management and risk prevention are risk mitigation strategies based on monitoring and collaboration, as well as the application of common measures resulting from them. (22.) The implementation of risk assessment methods intends to provide managers with support in their assessment and decision-making processes. (23.) Resilience by teaming framework is a concept that promotes the joint implementation of measures to increase resilience in the supply network. (41.) During the COVID-19 crisis, deficiencies in preparedness, insufficiencies in the current response plans, and the need for resilience in the supply chain could be identified. (43.) Firms need to address the development of supply chain risk management practices to mitigate the disturbing impact of risk events. Firms need to do this at macro and network levels.

Table 4 Summary of the derived main finding categories as well as the associated subcategories, which contain the relevant findings of the 45 identified articles (continued)

Main finding categories	*1. Strategic guidance of collaboration network*	*2. Structural and operational management of collaboration*	*3. Risk assessment and management in the collaborative network*
Sub-topic areas including linked overall statements from article findings	*1.2: Defining goals and transforming the strategy into operational measures* (2.) Soon after the appropriate strategy has been identified and implemented throughout the network, the next step is to define the operational measures in accordance with the participating firms. (4.) In addition to the basic management of orientation, it also requires the derivation of operational initiatives that are aligned across the involved organisations and that promote the higher-level objectives of the network. (9.) The operational activities and objectives, which concern the development of the ability to react quickly to specific risk incidents, form the basic principles behind supply chain risk management. (27.) The strategically embedded capabilities of agility, collaboration, and risk awareness also include the operational derivation of actions aimed to achieve the defined objectives in the collaboration.	*2.2: Commitment and contribution in the collaboration* (3.) A common understanding and approach to accomplishing network tasks are essential for crisis management. (6.) Collaborative communication, co-created knowledge, and shared relationship efforts promote supply chain resilience through increased speed and flexibility. (25.) A collaborative and effective business model that includes equitable benefit sharing is a necessity for the supply chain in horizontal logistics. (26.) Collective thinking and agreement on superior values are important factors for the establishment and development of collaboration. The contribution of individual companies helps maintain collaboration in the network. (33.) Relationship management in collaboration is crucial. Even before crises occur, more capabilities need to be increased so that activities management becomes more effective in times of disruptions. (35.) Collaborative elements in exercises contribute to perceived learning that has a subsequent impact on crises management activities. (40.) Effective collaboration across the organisation provides opportunities to embed the lessons learned during the COVID-19 pandemic. (42.) To enhance a network's resilience, the focus needs to be on cross-functional integration. Partners increasingly engage in collaboration exercising capabilities such as flexibility, adaptability, and agility, as well as the willingness to commit in inter-organisational networking. (45.) The commonly contributed synchronisation of the IT infrastructure and the derived integrated supply chain processes are the primary drivers of supply chain collaboration.	*3.2: Knowledge and information about potential risks in the operating business field* (14.) Key challenges to developing more effective supply chain management practices are classified into learning, strategy, coordination and measurement issues, and a simple, functional model can be developed to understand how collaboration between business partners can assist in overcoming supply chain management difficulties. (15.) The knowledge of risks and a willingness to share information in collaboration are necessary for the effective application of risk management and risk prevention. (43.) Firms need to focus on understanding the root causes of risk events. Once these risk events are identified, subsequent response mechanisms should be developed.

Table 4 Summary of the derived main finding categories as well as the associated subcategories, which contain the relevant findings of the 45 identified articles (continued)

Main finding categories	*1. Strategic guidance of collaboration network*	*2. Structural and operational management of collaboration*	*3. Risk assessment and management in the collaborative network*
Sub-topic areas including linked overall statements from article findings	*1.3: Cultural development and consolidation* (16.) Shared supply chain orientation significantly influences learning and development as well as the culture of risk management in the supply chain. (28.) The findings indicate that joint problem solving, and measurements are essential for developing a culture of collaboration and conducting effective planning. (37.) To reduce the barriers to collaboration, it is important to implement a cross-cultural approach. An open-door policy and clear rules regarding collaboration are also vital.	*2.3: The deployment of operational resources* (17.) The collaborative approach and the joint effort across the extended enterprise help deal with volatility in the network. An important prerequisite for flexible supply chain management is the ability to access additional resources and capacity when needed. (29.) The role of inventory and slack in the supply chain is to mitigate the impact of disruption. If the stocks of the affected items are sufficient at the time of the crisis, the impact of the disruption would be reduced. (30.) Technology, which is implemented and used across the network, has a significant impact on supply chain collaboration and operational performance.	*3.3: The evaluation and assessment as well as the management of known risks* (5.) Risk mitigation processes are critical in building a resilient supply chain. To implement risk mitigation processes, existing crises need to be analyzed and evaluated, in order to have the appropriate response in place to prevent upcoming risks. (19.) Dependence on a single supplier as well as poor relationships with suppliers and poor risk management contribute to supply chain crises.

Table 4 Summary of the derived main finding categories as well as the associated subcategories, which contain the relevant findings of the 45 identified articles (continued)

Main finding categories	*1. Strategic guidance of collaboration network*	*2. Structural and operational management of collaboration*	*3. Risk assessment and management in the collaborative network*
Sub-topic areas including linked overall statements from article findings	*1.4: The creation and use of know-how capabilities* (8.) Turbulence creates risks, but these risks also provide opportunities. Uncertainty cannot be avoided, whereas the risk it involves can be controlled. The key is to develop an awareness of risk and know-how that can be implemented across company boundaries. (9.) Firms must invest in their human resources to enable employees to recognise changing environments and adapt quickly to trends. (10.) Managers have to improve their acknowledgement of responsibility, social management skills, and risk and supply chain performance to understand the relationship between these areas in supply chain management. (13.) Evaluating combinations of both technology and collaboration along a risk-reward horizon should be done to provide specific knowledge to managers to explore this tradeoff. (18.) Knowledge creation in an organisation and its transfer in the supply chain promote a resilient supply chain. (21.) Supply chain professionals in Australia have high levels of education but limited management background in supply chain operations. (34.) Flexible and responsive processes are becoming increasingly important. Knowledge management and knowledge transfer are essential in this context. (37.) It is vital to promote knowledge transfer to reduce barriers to collaboration.	*2.4: The exchange of communication and information in the collaboration* (6.) Collaborative activities such as information sharing promote supply chain resilience through increased visibility and speed. (11.) Risk information sharing and the risk sharing mechanism are related to financial performance. A common understanding of supply chain risk management increases the effectiveness of the risk sharing mechanism. (12.) Commonly used IT infrastructure and information sharing are becoming increasingly important for identifying supply chain risks. (17.) Visibility and information sharing are crucial factors in dealing with volatility in the network. Visibility and transparency are needed along the entire supply chain. (20.) A continuous flow of information from suppliers to end users allows critical capabilities to be combined to deliver services that add value for participants.	

Table 4 Summary of the derived main finding categories as well as the associated subcategories, which contain the relevant findings of the 45 identified articles (continued)

Main finding categories	*1. Strategic guidance of collaboration network*	*2. Structural and operational management of collaboration*	*3. Risk assessment and management in the collaborative network*
Sub-topic areas including linked overall statements from article findings	*1.5: The incentives and (contractual) binding of participants as well as the power imbalance in the network* (32.) Power imbalance in supplier relationships, regulated by various contracts, influences the efficiency of the supply chain as well as the overall performance. (36.) A significant positive relationship is observed between technological uncertainty and supplier involvement. Buyer dependence and interdependence are also found to positively influence the relationship between technological uncertainty and supplier involvement.	*2.5: The implementation and integration of operational systems or processes* (3.) Cross-company processes that are aligned with each other are required to enable the joint processing of cross-network tasks. (39.) The focus should be on a holistic approach that considers the entire service ecosystem as well as individual challenges and available resources to manage crises. (42.) In terms of building resilience in the supply chain, cross-functional integration is linked here as a supportive component. This includes, for example, cross-functional training, the recognition of interdependence, the consideration of informal groups, cross-functional meetings, or appropriate communication. (44.) There is a need for cross-functional integration in jointly executed processes.	

About 19 articles (42%) were assigned to main finding category one (strategic guidance of collaboration network) and 25 overall statements were linked across five sub-topic areas. 17 articles (38%) were designated to main finding category two (structural and operational management of collaboration) and here 27 overall statements were connected across five sub-topic areas. The third main finding category (risk assessment and management in the collaborative network) includes the remaining nine articles (20%) and 13 overall statements were connected across three sub-topic areas.

4.5 Examination of sample data in relation to network/firm insights

In this paragraph, the used data samples in the articles were investigated. The derived basic data set can be found in the Appendix. A special interest was shown in investigating the following topics: network extension of collaboration (global versus local), the firm size of network participants [large (>500 employees) versus small- and medium-sized enterprises (SMEs)] and the industry segment.

The analysis linked to the network extension and comparison among global and local operating networks shows that, 24 articles (53%) are assigned to global orientation, 16 articles (36%) are assigned to local orientation, and five articles (11%) deliver no specific information. The investigation linked to the firm size of participants showed that, 34 of the 45 articles (76%) examined large enterprises, six articles (13%) examined small to medium-sized enterprises, while no information was available for the remaining five articles (11%). In the next step, the examination of the industry segment took place. This segment was categorised into the following clusters: 1. commerce/trading, 2. manufacturing of goods, 3. media, 4. healthcare, 5. service operations, and 6. finance obligations. In case multiple industries are mentioned within the articles, they have been assigned to 7. multiple industries mentioned. If no detailed information is available, the articles were assigned to 8. no specific information. The results from the defined clusters are chronologically explained below. The cluster with the particularly maximum number of results can be linked to service operations with 12 articles (27%). Ten articles (22%) are linked to the cluster manufacturing of goods. The cluster commerce/trading contains five articles (11%), whereas one article each (2%) was assigned to the cluster's media, healthcare and finance obligations. The cluster multiple industries include 12 out of 45 articles (27%). The remaining cluster with no specific information includes three articles (7%). Both clusters seven and eight could not be considered further in the evaluation.

No area of concentration was found with respect to the research theories employed. For example, the agency theory and the resource dependence theory were used in three articles each, whereas the contingency theory and the graph theory were used in two articles each. In 20 articles, no research theory was applied or clearly specified. However, it is evident that multiple diverse supply chain theories are being applied. With regard to the business focus, no further analysis can be performed as well, as the results are too diverse. Different sectors have been addressed throughout the analysed articles.

5 Discussion

In this section of the literature review, we deeper examine and connect the gained knowledge of the previous mentioned findings related to the development of the research area, the research methods and methodology applied, the relation of the articles to the

publishing journals as well as the classification of the main finding categories and their sub-topic areas. Furthermore, we link the extracted information from the databases used in the articles, so that overall statements on the network extension, the firm size, and the underlying industry segment were possible. This coherent knowledge can then be used to determine framework conditions for the network alignment and the holistic design of the collaboration in order to strengthen the supply network in terms of resilience and robustness.

5.1 Research implications

5.1.1 Research field development

Various authors have independently addressed the derived main finding categories, connected them to each other, and discussed the issue of crises in supply chain collaboration. Major crises, such as those described in the above section, repeatedly trigger this research field, and stimulate the interest of the research community to provide scientific contributions. Our study reveals that the researched area is still evolving. In fact, the topic is being researched more frequently in recent times, as several industries are facing crises (Campbell, 2020; Da Silva Poberschnigg et al., 2020).

5.1.2 Research methods and methodology applied

The identification of the main research methods indicates the process of knowledge creation within this research discipline. The methods used have been clearly stated and rated – this may be considered as a reference for researchers providing future studies in this specific area. There is no indication of preference in the choice of methodological approach (qualitative vs. quantitative) for investigating a related research issue. Depending on what specific collaboration network area is being studied (strategic, operational, or in terms of risk management), the methodological approach used will be chosen afterwards accordingly.

5.1.3 Articles and their journals reference

The top three journals can be considered as a central point of reference for the study and for publication of this research discipline. Moreover, the focus within the top journals in terms of the research method and methodology used was described. It is noticeable that the publications are predominantly qualitative investigated. However, the identified articles are equally distributed in terms of the research methodology used. This can be due to the fact that the journals mainly publish or prioritise descriptive papers on this research area and quantitative articles are published elsewhere in other journals with respective focus. The applied research methods are equally distributed, except for the top journal (*Supply Chain Management: An International Journal*), which mainly uses case studies and interviews/surveys to create research content. The International Journal of Physical Distribution & Logistics Management, in particular, addressed the research issue at an early stage - already at its inception. The two other journals, however, recognised the publication interest later and exploited its potential accordingly. For all journals, the research interest remains until today. This serves, primarily, as a point of reference for future literature reviews, in order to consolidate created knowledge in a structured approach. The strategic and operational aspects related to supply chain collaboration

during times of crisis is equally addressed in the top journals. Risk and risk management is rather neglected.

5.1.4 Main finding category and the linked sub-topic areas

The following paragraphs examine the main finding categories and the linked sub-topic areas, which are intended to serve as a starting point for the design of resilient and robust supply networks. The first step involves the consideration of the main finding categories as well as all their sub-topic areas, and in the subsequent step, the most important findings are elaborated and mentioned as a focus point for network design.

Strategic guidance of collaboration network

The sub-topic area 1.1 (the prioritisation of the core strategic elements and strategy adjustment) represents the room for initiatives for the strategic orientation of business. The strategic target definition should be comprehensive, so that all participating organisations are involved in the formulation of the overall strategic path (Scholten et al., 2014). The sub-topic area 1.2 (defining goals and transforming the strategy into operational measures) addresses the issue of derivation of the strategic path in operational actions. Holistic actions need to be defined, as this promotes the achievement of the strategically defined goals. The effectiveness of the defined actions is to be reviewed continuously. These derived actions are tied to key performance indicators, and hence, if necessary, corrective actions need to be initiated (Bealt et al., 2016). The sub-topic area 1.3 (cultural development and consolidation) is linked to open communication and uncomplicated collaboration across organisational boundaries. A jointly developed, shared culture with values and attitudes needs to be established (Camarinha-Matos et al., 2008). The sub-topic area 1.4 (the creation and use of know-how capabilities) reflects the need for creating sustainable knowledge for the organisation, and embedding this knowledge within the supply chain. The knowledge created should be stored on suitable knowledge management platforms and be made available across all participants in the collaboration. Moreover, it refers to investing in human capital and creating a supportive learning environment (Da Silva Poberschnigg et al., 2020). The remaining sub-topic area 1.5 (the incentives and (contractual) binding of participants as well as the power imbalance in the network) suggests that an honest relationship and mutual respect enable collaboration on an equal basis. In particular, the power imbalance between buyer and supplier or the imbalance experienced among smaller and larger participants in the collaboration needs to be resolved, wherever feasible. Risks, losses, as also gains from the collaborative effort require adequate and fair sharing (Kilubi and Rogers, 2018).

Structural and operational management of collaboration

The results from the sub-topic area 2.1 (trust in the collaboration and its participants) reflect the need for fundamental trust and reliability among the participants. Trust and reliability can be seen as key factors in enabling common business activities. Mutual trust and reliability strengthen the relationship and enable deeper synergies among collaborating firms (Kumar et al., 2017). The sub-topic area 2.2 (commitment and contribution in the collaboration) indicates the demand for the operational execution of the actions and processes within the network. Each partner is appropriately committed

and accordingly contributes their value to the collaboration. Participation and involvement are important factors in organisational collaboration (Klassen and Vereecke, 2012). The sub-topic area 2.3 (the deployment of operational resources) highlighted that, shared resources within the network promote flexibility and improve responsiveness under various challenging conditions. Furthermore, pooling resources and providing technology across organisational boundaries promotes end-to-end utilisation and enhances operational performance. The network is less affected by fluctuations in demand (Finsterwalder and Kuppelwieser, 2020). The sub-topic area 2.4 (the exchange of communication and information in the collaboration) refers to the need for willingly sharing the required information, if there is a demand. Moreover, it includes exposure to detailed knowledge, which is required for daily collaborative routines. An intact communication behaviour creates efficiency in continuous alignment and reduces additional coordinative efforts (Levalle and Nof, 2015). The remaining sub-topic area 2.5 (The implementation and integration of operational systems or processes) identifies the demand for adaptable and compatible operating processes, when it comes to implementing network-wide actions. Harmonised systems, which are able to be deployed across organisational boundaries, are gaining ground and creating a more robust architecture (Camarinha-Matos et al., 2008).

Risk assessment and management in the collaborative network

The sub-topic area 3.1 (risk prevention and risk management measures) indicates the demand for appropriate preparations and adequate responses to risk situations. In addition, dealing with future network-related scenarios and evaluating the volatility of collaboration are mentioned (Christopher and Holweg, 2017; Sawyerr and Harrison, 2019). The sub-topic area 3.2 (knowledge and information about potential risks in the operating business field) reflects the need to recognise emerging crisis at an early point in time, and subsequently classify them appropriately. The willingness to share risk-relevant information and to operate in a harmonised manner is seen as particularly relevant in this context (Fischer-Preßler et al., 2020). The last sub-topic area 3.3 (the evaluation and assessment as well as the management of known risks) demonstrates the need for developing a common and deeper understanding of crisis patterns, in order to describe the situation within the network more appropriately. This, in return, enables suitable responses to be defined jointly. The evaluation of these activities at the end serves as learning for future crisis and their management (Skipper and Hanna, 2009; Li et al., 2015).

The first two main finding categories focus on topics linked to the design and adjustment of collaborative networks, and these receive the overwhelming majority of attention. In the first main category, the focus needs to be on the core topics on the strategic orientation and alignment of collaboration (Scholten et al., 2014), as shown by the sub-topic areas and the corresponding statements derived from the article findings. Equally important is knowledge management and the creation of know-how in collaboration. The generation of know-how and its broad distribution in the supply chain supports crisis management (Da Silva Poberschnigg et al., 2020). In the second main category, the emphasis is on participation and involvement of participants in collaborative network. It is important to create an environment that is conducive to the voluntary participation of participants (Klassen and Vereecke, 2012). Nevertheless, the third category is not negligible, as it contains one-fifth of the total number of articles.

Therefore, it can be argued that the third category is equally important in terms of the design and adjustment of the collaborative network, but is more focused on the framework conditions in the network's design. The focus is primarily on the detection of risks. The ability to recognise risks early as possible and the adequate responsiveness of the entire network are the vital factors to prevent holistic damage to the network (Fischer-Preßler et al., 2020). After a crisis has been successfully averted or contained, it is important to retrospectively evaluate the activities taken. This creates knowledge about the effectiveness of the measures and also provides information on improved procedures for future incidents (Skipper and Hanna, 2009; Li et al., 2015).

5.1.5 Sample data of networks/firms and their connection to main finding categories

In this step, the results from the network extension of collaboration, the firm size of network participants and the industry segment were linked across the main finding categories and also within the sub-topic areas, in order to get deeper insights into economic relationship.

The main finding category one (strategic guidance of collaboration network) is more often linked to globally-oriented networks than to local ones. Global networks are required to operate more closely together on a long-term scale, to compensate for coordination effort and communication barriers resulting from cultural and geographical distance (Kilubi and Rogers, 2018). Therefore, the alignment of the strategic framework across globally settled firms needs more focus than locally designed networks (Scholten et al., 2014). The main finding category two (structural and operational management of collaboration) is equally linked to both network extensions. Therefore, this is equally important for both local and global networks. The operational and tactical organisation of workflow content and processes is a key concern for any network, regardless of its extension. This is a basic prerequisite for successful economic activity (Camarinha-Matos et al., 2008). The main finding category three (risk assessment and management in the collaborative network) is more often linked to globally oriented and connected networks than to local ones. Globally-oriented networks are more susceptible to disruptions because communication paths are extended, and it is more difficult to implement short-term harmonised responses (Sawyerr and Harrison, 2019). In addition, the tendency towards higher delivery times within global networks deserves to be mentioned as well. The overall recovery process is slower due to the additional cross-country influencing factors. Therefore, international influence is a critical key factor in strengthening the resilience and robustness of global networks (Campbell, 2020). In more detail, globally operating networks have been particularly often-researched in the sub-topic area "The prioritisation of the core strategic elements and strategy adjustment", "The creation and use of know-how capabilities" and "Risk prevention and risk management measures". For globally aligned supply chains, these are the three most relevant aspects in terms of the alignment of the collaborative network. Addressing these topics will help build a more resilient and robust ecosystem. Locally-oriented networks have been particularly often researched in the sub-topic area "Commitment and contribution in the collaboration". For local supply chains, the involvement of individual participants and their participation in the network are of key relevance. This might be the appropriate basis to ensure a crisis-resistant collaboration.

The majority of the firms in the articles can be linked to large-sized networks. All three main finding categories show a tendency to be more important for large firms than for small and medium-sized enterprises. Large enterprises have been particularly often researched in the sub-topic areas "Commitment and contribution in the collaboration", "The prioritization of the core strategic elements and strategy adjustment", "The creation and use of know-how capabilities", and "Risk prevention and risk management measures." The results within the sub-topic areas are similar to those of globally-oriented networks. The most important points include operational/tactical compliance and alignment, derivation and implementation of a common strategy, knowledge creation and distribution in the network, as well as risk prevention and management. For small and medium- sized firms, no outstanding value could be found in the allocations; it is equally distributed across the sub-topic areas.

For the industry cluster service operations, the second main finding category and more specific the sub-topic areas "Commitment and contribution in the collaboration" and "The exchange of communication and information in the collaboration" are particularly often researched. Key issues include the willingness of an organisation to engage in collaboration and the readiness to share information along the supply network (Klassen and Vereecke, 2012; Fischer-Preßler et al., 2020). For the industry cluster manufacturing of goods, the second main finding category and more specific the sub-topic areas "Commitment and contribution in the collaboration" and "The implementation and integration of operational systems or processes" are often researched. The willingness of an organisation to engage in collaboration as well as the implementation and integration of operational systems are equally relevant. The second point, in particular, poses a special challenge for manufacturing firms. On the one hand, it is necessary to produce cost-effective and efficient, and on the other hand, it is vital to respond fully flexibly to diverse customer needs. This area of conflict is increasingly moving into the focus of manufacturing networks (Klassen and Vereecke, 2012; Camarinha-Matos et al., 2008). For the industry cluster commerce/trading, the second main finding category and more specific the sub-topic areas "Trust in the collaboration and its participants" and "Commitment and contribution in the collaboration" are more frequently examined. Specifically, it is about trust in the collaboration and between the professionals in the network as well as the willingness of an organisation to participate in the supply network so that a properly operating partnership will be achieved (Kumar et al., 2017; Klassen and Vereecke, 2012). In the top three linked industry clusters the sub-topic area "Commitment and contribution in the collaboration" is mentioned. Therefore, this can be seen as a vital, industry-independent factor for success along the collaborative network in times of crisis. The clusters "media, health care and finance obligations" contain, in each case, one assigned article; therefore, no further valid derivation of results is feasible.

5.2 Future research avenues

Table 5 presents opportunities across various research areas and topics connected to our subject of study. The left side indicating major areas of interest and the right side contains detailed descriptions of the opportunities identified.

Table 5 Future research agenda

Research area and topic		*Detailed description*
Supply chain collaboration: Initialisation	1	Define requirements for layout and application or implementation in the conception of the network
	2	Investigate how the partner selection, classification and integration process can be redesigned in order to fit the requirements in volatile environment
	3	Identify specific features in volatile circumstances that imply one of the two types of collaboration
Supply chain collaboration: Operative management	1	Specify the downstream coordination tasks and harmonise with regard to the information to be distributed
	2	Define the required resources for operative network alignment
	3	Set up the operational key figures, which can be used to manage and monitor partners in terms of their performance
Supply chain collaboration: Risk management	1	Definition of risk indicators for early identification of upcoming risks for the logistic network
	2	Define appropriate measures to mitigate the impact on the logistics network
Supply chain collaboration: Termination of collaboration	1	Set up guidelines to evaluate the work relationship; create continuous learning and future avoidance of failures
	2	Deep integrated firms are tightly connected in terms of work processes; therefore, define a separation approach

5.3 Conclusions

The crisis resistance of collaborative supply networks can be improved with various activities. These activities differ depending on the extension of the network, the size of the firms involved and the underlying industry segment. This literature review presented key areas for decision-makers to focus in terms of design adjustment of the supply network in order to increase its resilience and robustness linked to the networks internal and external environment.

We were able to determine that global crisis events triggering this research area and stimulate the interest of the research community to provide scientific contributions. Nevertheless, the existing literature reveal, that the majority of the research discipline is not yet been reached. The development of the research field is ongoing and deeper knowledge is required to deliver progress (Campbell, 2020; Da Silva Poberschnigg et al., 2020).

The fundamental characteristics of the research field were analysed and structured correspondingly. Consequently, the first part of the defined research objective and question was successfully completed.

The data derived from the identified articles in terms of network extension, firm size, and industry segment, in combination with the result of the coherent examination of the main finding categories as well as the sub-topic areas, provide the action framework for the holistic design and alignment for various supply networks to create a robust and resilient collaborative environment. The combined and derived elements are to be considered in advance when initialising collaboration, and they can be used to rate and

select potential collaborators in terms of value fit with the focus firm. If the network already exists, these core areas serve as guiding approaches to align the existing structures. The main finding categories derived are higher-level guiding approaches, which need to be further specified depending on collaboration and the underlying economic environment. The sub-topic areas and the related information linked to the network extension, the firm size, as well as the industry segment provide knowledge about the specific scope of the central topics in supply chain configurations. Specific subjects can be examined in detail, to identify potential fields of development within the network, in order to build a resilient and robust supply network. Alignment with these basic elements, therefore, is key to successfully determining the long-term perspectives for collaborative programs.

With reference to the second part of the research objective and question, it was possible to define the basic requirements for network design in collaborative interactions during crisis.

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Appendix

List of the 45 identified articles for this literature review

Articles mentioned with their research methodology, publication year as well as local and global citation scores are presented in Table 6.

Table 6 Detailed overview of articles

Running number	*Title*	*Author*	*Journal*	*Research methodology*	*Year*	*LCS*	*GCS*
1	Supply chain resilience in the global financial crisis: An empirical study	Jüttner, U. and Maklan, S.	*Supply Chain Management: An International Journal*	Qualitative	2011	10	305
2	Global supply chain risk management strategies	Manuj, I. and Mentzer, J.T.	*International Journal of Physical Distribution & Logistics Management*	Qualitative	2008	7	417
3	Exploring the role of social capital in facilitating supply chain resilience	Johnson, N., Elliott, D. and Drake, P.	*Supply Chain Management: An International Journal*	Qualitative	2013	5	113
4	The supply chain crisis and disaster pyramid: A theoretical framework for understanding preparedness and recovery	Richey, R. and Glenn, Jr.	*International Journal of Physical Distribution & Logistics Management*	Qualitative	2009	4	42
5	Mitigation processes – Antecedents for building supply chain resilience	Scholten, K., Scott, P.S. and Fynes, B.	*Supply Chain Management: An International Journal*	Qualitative	2014	4	146
6	The role of collaboration in supply chain resilience	Scholten, K. and Schilder, S.	*Supply Chain Management: An International Journal*	Qualitative	2015	4	165
7	Minimizing supply chain disruption risk through enhanced flexibility	Skipper, J.B. and Hanna, J.B.	*International Journal of Physical Distribution & Logistics Management*	Quantitative	2009	3	98
8	"Supply Chain 2.0": Managing supply chains in the era of turbulence	Christopher, M. and Holweg, M.	*International Journal of Physical Distribution & Logistics Management*	Quantitative	2011	3	265
9	Supply chain risk management in financial crises – A multiple case-study approach	Blome, C. and Schoenherr, T.	*International Journal of Production Economics*	Qualitative	2011	2	101
10	Social issues in supply chains: Capabilities link responsibility, risk (opportunity), and performance	Klassen, R.D. and Vereecke, A.	*International Journal of Production Economics*	Qualitative	2012	2	266
11	Joint supply chain risk management: An agency and collaboration perspective	Li, G., Fan, H., Lee, P.K.C. and Cheng, T.C.E.	*International Journal of Production Economics*	Quantitative	2015	2	98
12	A critical balance: Collaboration and security in the IT-enabled supply chain	Smith, G.E., Watson, K.J., Baker, W.H. and Pokorski II, J.A.	*International Journal of Production Research*	Qualitative	2007	1	76
13	Assessing interfirm collaboration/technology investment tradeoffs. The effects of technological readiness and organizational learning	Richey, Jr, R.G. and Autry, C.W.	*The International Journal of Logistics Management*	Quantitative	2009	1	58

Note: Local citation score (LCS) and global citation score (GCS) according to times cited in Web of Science Core Collection, extracted on May 24, 2021

Table 6 Detailed overview of articles (continued)

Running number	*Title*	*Author*	*Journal*	*Research methodology*	*Year*	*LCS*	*GCS*
14	Developing supply chains in disaster relief operations through cross-sector socially oriented collaborations	Maon, F., Lindgreen, A. and Vanhamme, J.	*Supply Chain Management: An International Journal*	Qualitative	2009	1	118
15	Mitigation, avoidance, or acceptance? Managing supplier sustainability risk	Hajmohammad, S. and Vachon, S.	*Journal of Supply Chain Management*	Qualitative	2016	1	69
16	Supply chain readiness, response and recovery for resilience	Chowdhury, M.H. and Quaddus, M.	*Supply Chain Management: An International Journal*	Quantitative	2016	1	41
17	Supply chain 2.0 revisited: A framework for managing volatility-induced risk in the supply chain	Christopher, M. and Holweg, M.	*International Journal of Physical Distribution & Logistics Management*	Quantitative	2017	1	40
18	Building routines for non-routine events: Supply chain resilience learning mechanisms and their antecedents	Scholten, K., Scott, P.S. and Fynes, B.	*Supply Chain Management: An International Journal*	Qualitative	2019	1	23
19	Decision making in advance of a supply chain crisis	Hittle, B. and Leonard, K.M.	*Management Decision*	Quantitative	2011	0	12
20	A manufacturer moving upstream: Triadic collaboration for service delivery	Finne, M. and Holmström, J.	*Supply Chain Management: An International Journal*	Qualitative	2013	0	60
21	Developing competencies of supply chain professionals in Australia: Collaboration between businesses, universities and industry associations	Sohal, A.S.	*Supply Chain Management: An International Journal*	Quantitative	2013	0	30
22	Assessing disaster risks in supply chains	Lockamy III, A.	*Industrial Management & Data Systems*	Quantitative	2014	0	34
23	A resilience by teaming framework for collaborative supply networks	Levalle, R.R. and Nof, S.Y.	*Computers & Industrial Engineering*	Quantitative	2015	0	12
24	The impact of supply chain disruptions on stockholder wealth in India	Kumar, S., Liu, J. and Scutella, J.	*International Journal of Physical Distribution & Logistics Management*	Quantitative	2015	0	15
25	Horizontal logistics collaboration for enhanced supply chain performance: An international retail perspective	Rodrigues, V.S., Harris, I. and Mason, R.	*Supply Chain Management: An International Journal*	Qualitative	2015	0	22
26	On the conditions for the cooperative relations between family businesses: The role of trust	Hadjielias, E. and Poutziouris, P.	*International Journal of Entrepreneurial Behavior & Research*	Qualitative	2015	0	9
27	Supply network disruption and resilience: A network structural perspective	Kim, Y., Chen, Y-S. and Linderman, K.	*Journal of Operations Management*	Quantitative	2015	0	201

Note: Local citation score (LCS) and global citation score (GCS) according to times cited in Web of Science Core Collection, extracted on May 24, 2021

Table 6 Detailed overview of articles (continued)

Running number	*Title*	*Author*	*Journal*	*Research methodology*	*Year*	*LCS*	*GCS*
28	Joint planning and problem-solving roles in supply chain collaboration	Kumar, G., Banerjee, R.N., Meena, P.L. and Ganguly. K.K.	*IIMB Management Review*	Quantitative	2017	0	14
29	The effect of the Rana Plaza disaster on shareholder wealth of retailers: Implications for sourcing strategies and supply chain governance	Jacobs, B.W. and Singhal, V.R.	*Journal of Operations Management*	Quantitative	2017	0	47
30	The mediating role of supply chain collaboration on the relationship between technology, trust and operational performance. An empirical investigation	Salam, M.A.	*Benchmarking: An International Journal*	Quantitative	2017	0	21
31	The impact of risk management on the frequency of supply chain disruptions. A configurational approach	Revilla, E. and Saenz, M.J.	*International Journal of Operations & Production Management*	Quantitative	2017	0	41
32	Supply chain models with corporate social responsibility	Wu, Y., Li, H., Gou, O. and Gu, J.	*International Journal of Production Research*	Quantitative	2017	0	17
33	Developing country sub-supplier responses to social sustainability requirements of intermediaries: Exploring the influence of framing on fairness perceptions and reciprocity	Soundararajan, V. and Brammer, S.	*Journal of Operations Management*	Qualitative	2018	0	23
34	Bridging the gap between supply chain risk management and strategic technology partnering capabilities: Insights from social capital theory	Kilubi, I. and Rogers, H.	*Supply Chain Management: An International Journal*	Qualitative	2018	0	8
35	Learning and usefulness stemming from collaboration in a maritime crisis management exercise in Northern Norway	Magnussen, L.I., Carlstrom, E. and Sorensen, J.L.	*Disaster Prevention and Management*	Quantitative	2018	0	12
36	Technology uncertainty in supply chains and supplier involvement: The role of resource dependence	Xiao, C., Petkova, B., Molleman, E. and Van der Vaart, T.	*Supply Chain Management: An International Journal*	Quantitative	2019	0	5
37	A hybrid framework for ranking the knowledge management solutions adoption in supply chains	Raad, N.G. and Shirazi, M.A.	*Vine Journal of Information and Knowledge Management Systems*	Quantitative	2019	0	1
38	Achieving triple bottom line sustainability in supply chains. The role of environmental, social and risk assessment practices	Miemczyk, J. and Luzzini, D.	*International Journal of Operations & Production Management*	Quantitative	2019	0	11
39	Equilibrating resources and challenges during crises: A framework for service ecosystem well-being	Finsterwalder, J. and Kuppelwieser, V.G.	*Journal of Service Management*	Qualitative	2020	0	14

Note: Local citation score (LCS) and global citation score (GCS) according to times cited in Web of Science Core Collection, extracted on May 24, 2021

Table 6 Detailed overview of articles (continued)

Running number	*Title*	*Author*	*Journal*	*Research methodology*	*Year*	*LCS*	*GCS*
40	Rethinking professional collaboration and agency in a post-pandemic era	Campbell, P.	*Journal of Professional Capital and Community*	Qualitative	2020	0	3
41	Research opportunities for a more resilient post-COVID-19 supply chain – Closing the gap between research findings and industry practice	Van Hoek, R.	*International Journal of Operations & Production Management*	Qualitative	2020	0	34
42	How can cross-functional integration support the development of resilience capabilities? The case of collaboration in the automotive industry	Da Silva Poberschnigg, T.F., Pimenta, M.L. and Hilletofth, P.	*Supply Chain Management: An International Journal*	Qualitative	2020	0	4
43	Managing environmental uncertainty for improved firm financial performance: The moderating role of supply chain risk management practices on managerial decision making	Singh, N.P.	*International Journal of Logistics Research and Applications*	Quantitative	2020	0	4
44	Demand management: The role of cross-functional integration in a context of political turbulence	De Freitas, M.R., Pimenta, M.L., Hilletofth, P., Jugend, D. and Oprime, P.C.	*Asia Pacific Journal of Marketing and Logistics*	Quantitative	2020	0	2
45	How important are supply chain collaborative factors in supply chain finance? A view of financial service providers in China	Ma, H-L., Wang, Z.X. and Chan, F.T.S.	*International Journal of Production Economics*	Qualitative	2020	0	19

Note: Local citation score (LCS) and global citation score (GCS) according to times cited in Web of Science Core Collection, extracted on May 24, 2021

Additional data extracted linked to the 45 identified published articles

The 45 selected articles with their theories applied, network extension, firm size, industry segment and business focus are presented in Table 7.

Table 7 Additional data extraction of 45 identified published articles

Running number	*Theories applied*	*Network extension: global versus local*	*Firm size: large (>500) versus SME*	*Industry segment*	*Business focus*
1	Link to Theory	Local	SME	2. Manufacturing of goods	Electronic; Chemical & Wood working industry
2	Qualitative interviews using grounded theory methodology	Global	Large	2. Manufacturing of goods	Electronic, Pharmaceutical, Office products, Heavy equipment & Consumer goods
3	No information provided	Local	Large	5. Service operations	Public transportation
4	Relationship management theory; Communication theory; Competing values theory	Local	Large	8. No specific information	No specific information
5	Bridge theory – Network supply chain resilience	Local	SME	4. Health care	Humanitarian logistics
6	Conceptual supply chain resilience theory	Local	Large	2. Manufacturing of goods	Food processing industry
7	Contingency theory	Local	Large	5. Service operations	Government & Suppliers or service providers for government
8	Real options theory – Supply chain Planning	Global	Large	2. Manufacturing of goods	Trading, Electronic goods & car manufacturer
9	No information provided	Global	Large	7. Multiple industries mentioned	Trading, Manufacturing, Service Operations, Finance& Banking
10	Stakeholder theory	Global	Large	7. Multiple industries mentioned	Machinery, Food and beverage, Electronic equipment & Specialty chemicals
11	Agency theory perspective	Global	Large	7. Multiple industries mentioned	Trading, Consumer goods, Logistic services, Manufacturing, Pharm & Medical, Media & Construction
12	Classical decision theory	Global	Large	5. Service operations	IT – services in supply chain network
13	Salient theory from transaction cost economics	Global	Large	1. Commerce/trading	Retail
14	No information provided	Global	Large	5. Service operations	Logistic
15	Agency theory; Resource dependence theory	Global	1. commerce/trading	Retail	
16	Normal accident theory (NAT) and high reliability theory (HRT)	Global	Large	2. Manufacturing of goods	Apparel manufacturing & suppliers/accessory-producing
17	No information provided	Global	Large	5. Service operations	Logistic

Table 7 Additional data extraction of 45 identified published articles (continued)

Running number	*Theories applied*	*Network extension: global versus local*	*Firm size: large (>500) versus SME*	*Industry segment*	*Business focus*
18	No information provided	Global	Large	5. Service operations	Different service offering organizations
19	Supply chain crisis management theory	Global	Large	2. Manufacturing of goods	Automotive, Food processing industry & Electronic consumer goods
20	Supply chain management design theory	Global	Large	5. Service operations	Advanced industrial services
21	No information provided	Local	SME	7. Multiple industries mentioned	Food and Beverage, Trading, Logistic and Clothing
22	Combination of probability theory and graph theory	Global	Large	2. Manufacturing of goods	Automotive casting suppliers
23	Collaborative control theory	Local	Large	5. Service operations	Logistic and Supply
24	Efficient market theory	Global	Large	3. Media	Press and media
25	No information provided	Local	Large	7. Multiple industries mentioned	Retailer, retailers' suppliers and logistics and service providers
26	No information provided	Local	Large	1. Commerce/trading	Retail
27	Graph theory	No specific information	No specific information	8. No specific information	No specific information
28	Advancing contingency theory and force field theory	Local	Large	7. Multiple industries mentioned	Manufacturer, Wholesale / Distributor, Service Company and Retailer
29	No information provided	Local	Large	7. Multiple industries mentioned	Manufacturer, Wholesale / Distributor, Retailer, Trading and Logistic provider
30	No information provided	Local	SME	1. commerce/trading	Fast-moving consumer goods
31	No information provided	Global	Large	7. Multiple industries mentioned	Manufacturer, Retailer and Logistic service provider
32	Game theory	No specific information	No specific information	7. Multiple industries mentioned	Original Equipment Manufacturer, Retailer, Logistic service provider and Trading
33	Resource dependence theory and agency theory	Local	Large	1. Commerce/trading	Knitwear garment sub-suppliers
34	Social capital theory	No specific information	No specific information	8. No specific information	No specific information
35	No information provided	Local	Large	5. Service operations	Civil defence organizations, National Guard, Ambulance services, University Nord and Norwegian Society for Sea Rescue

Table 7 Additional data extraction of 45 identified published articles (continued)

Running number	*Theories applied*	*Network extension: global versus local*	*Firm size: large (>500) versus SME*	*Industry segment*	*Business focus*
36	Resource dependence theory	Global	Large	2. Manufacturing of goods	Metal parts and products, Machines and equipment, Office equipment and computers, electronic machines, Devices and appliances, Telecommunication devices and appliances, Medical devices and instruments and Cars and trailers
37	No information provided	Local	Large	5. Service operations	Dairy supply chain
38	No information provided	Global	SME	7. Multiple industries mentioned	Manufacturing, Information and communication, Finance and insurance and Professional, scientific and technical activities
39	No information provided	No specific information	No specific information	5. Service operations	Service ecosystems and organization of co-creation
40	No information provided	Local	SME	5. Service operations	Teachers, School leaders and Education systems
41	No information provided	Global	Large	7. Multiple industries mentioned	Transportation, Retail, Equipment manufacturing, Fast-moving consumer goods, Food manufacturing, Durable consumer products manufacturing, Apparel and Technology and software services
42	No information provided	No specific information	No specific information	2. Manufacturing of goods	Manufacturer of bearings and clutches and Suppliers
43	Institutional theory	Global	Large	7. Multiple industries mentioned	Chemical manufacturing, Pharmaceuticals, Healthcare manufacturing, Automotive manufacturing, Technology manufacturing, Food manufacturing, Service, Logistics and General manufacturing
44	No information provided	Global	Large	2. Manufacturing of goods	Automobile manufacturing
45	No information provided	Local	Large	6. Finance obligations	Financial service providers

Evaluation of article count in sub-topic areas

In Table 8, the article assignment within sub-topic areas can be found. On the left side the main finding categories are reflected; in the middle the 45 articles are assigned to the sub-topic areas; and on the right side, the count alongside the sub-topic areas can be found. The numbers in bold represent articles with linked results in two sub-topic areas.

Table 8 Overview of article count in sub-topic areas

Main finding categories		*Articles connected in sub-topic area*	*Total count*
1	Strategic guidance of collaboration network	1.1 (**2**, **4**, 7, **8**, 24, **27**, 31, 38)	1.1 (8)
		1.2 (**2**, **4**, **9**, **27**)	1.2 (4)
		1.3 (16, 28, **37**)	1.3 (3)
		1.4 (**8**, **9**, 10, 13, 18, 21, 34, **37**)	1.4 (8)
		1.5 (32, 36)	1.5 (2) → Articles total: 19
2	Structural and operational management of collaboration	2.1 (**11**, **12**, **25**, **26**, **30**, **45**)	2.1 (6)
		2.2 (**3**, **6**, **25**, **26**, 33, 35, 40, **42**, **45**)	2.2 (9)
		2.3 (**17**, 29, **30**)	2.3 (3)
		2.4 (**6**, **11**, **12**, **17**, 20)	2.4 (5)
		2.5 (**3**, 39, **42**, 44)	2.5 (4) → Articles total: 17
3	Risk assessment and management in the collaborative network	3.1 (1, **5**, **14**, **15**, 22, 23, 41, **43**)	3.1 (8)
		3.2 (**14**, **15**, **43**)	3.2 (3)
		3.3 (**5**, 19)	3.3 (2) → Articles total: 9

Evaluation of data sample from 45 articles

In Table 9, the ongoing analysis of data sample linked to the 45 articles takes place. Data linked to network extension, firm size and industry segment were extracted and assigned to the sub-topic areas. The numbers in bold represent articles with linked results in two sub-topic areas.

Table 9 Overview of extracted results from 45 articles

Main finding categories	*1. Strategic guidance of collaboration network*		*2. Structural and operational management of collaboration*		*3. Risk assessment and management in the collaborative network*	
Investigation focus			*Analysis linked to network extension*			
Network extension	*Global*	*Local*	*Global*	*Local*	*Global*	*Local*
Count in sub-categories	1.1: **2**, **8**, 24, 31, 38 1.2: **2**, **9** 1.3: 16 1.4: **8**, **9**, 10, 13, 18 1.5: 36	1.1: **4**, 7 1.2: **4** 1.3: 28, **37** 1.4: 21, **37** 1.5:	2.1: **11**, **12**, **25**, **26** 2.2: **25**, **26** 2.3: **17** 2.4: **11**, **12**, **17**, 20 2.5: 44	2.1: **30**, **45** 2.2: **3**, **6**, 33, 35, 40, **45** 2.3: 29, **30** 2.4: **6** 2.5: **3**	3.1: **14**, **15**, 22, 41, **43** 3.2: **14**, **15**, **43** 3.3: 19	3.1: 1, **5**, 23 3.2: 3.3: **5**
Articles total	11[1]	5	7	8	6	3
Investigation focus	*Analysis linked to firm size*					
Firm size	*Large*	*SME*	*Large*	*SME*	*Large*	*SME*
Count in sub-categories	1.1: **2**, **4**, 7, **8**, 24, 31 1.2: **2**, **4**, **9** 1.3: 16, 28, **37** 1.4: **8**, **9**, 10, 13, 18, **37** 1.5: 36	1.1: 38 1.2: 1.3: 1.4: 21 1.5:	2.1: **11**, **12**, **25**, **26**, **45** 2.2: **3**, **6**, **25**, **26**, 33, 35, **45** 2.3: **17**, 29 2.4: **6**, **11**, **12**, **17**, 20 2.5: **3**, 44	2.1: **30** 2.2: 40 2.3: **30** 2.4: 2.5:	3.1: **14**, **15**, 22, 23, 41, **43** 3.2: **14**, **15**, **43** 3.3: 19	3.1: 1, **5** 3.2: 3.3: **5**
Articles total	14	2	13	2	7	2

Notes: [1]In the first main finding category, 19 articles were linked. In the analysis linked to the network extension, in total (global and local) 16 articles were linked. The reason for the different numbers is because three articles deliver no information about the network extension. The sum of the row equals 40. In the remaining second and third main categories, another two articles (in addition to the three already found in the first main finding category) deliver no information about the network extension. This circumstance matches the analysis linked to firm size as well as the analysis linked to industry segment.

Table 9 Overview of extracted results from 45 articles (continued)

Main finding categories	*1. Strategic guidance of collaboration network*	*2. Structural and operational management of collaboration*	*3. Risk assessment and management in the collaborative network*
Investigation focus		*Analysis linked to industry segment*	
Count on article layer	Commerce/trading: 13	Commerce/trading: 26, 30, 33	Commerce/trading: 15
	Manufacturing of goods: 2, 8, 16, 36	Manufacturing of goods: 6, 42, 44	Manufacturing of goods: 1, 19, 22
	Media: 24	Service operations: 3, 12, 17, 20, 35, 39, 40	Health care: 5
	Service operations: 7, 18, 37	Finance obligations: 45	Service operations: 14, 23
Absolute sum on article layer	Commerce/trading: 1	Commerce/trading: 3	Commerce/trading: 1
	Manufacturing of goods: 4	Manufacturing of goods: 3	Manufacturing of goods: 3
	Media: 1	Service operations: 7	Health care: 1
	Service operations: 3	Finance obligations: 1	Service operations: 2
Articles total	9	14	7
Count of cluster in sub-topic areas	1.1: 2, 5, 2, 3	2.1: 5, 1, 1, 6	3.1: 2, 4, 5, 1, 2, 5
	1.2: 2	2.2: 5, 2, 1, 1, 5, 5, 2, 6	3.2: 5, 1
	1.3: 2, 5	2.3: 5, 1	3.3: 4, 2
	1.4: 2, 1, 5, 5	2.4: 2, 5, 5, 5	
	1.5: 2	2.5: 5, 5, 2, 2	

Notes: [1]In the first main finding category, 19 articles were linked. In the analysis linked to the network extension, in total (global and local) 16 articles were linked. The reason for the different numbers is because three articles deliver no information about the network extension. The sum of the row equals 40. In the remaining second and third main categories, another two articles (in addition to the three already found in the first main finding category) deliver no information about the network extension. This circumstance matches the analysis linked to firm size as well as the analysis linked to industry segment.