Supply Chain Integration: A Bibliometric Analysis

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Abstract. This paper examines the intellectual foundation of supply chain integration (SCI) and presents the most influential papers and authors of this research domain. The paper displays a visualization of the results of citation and co-citation analysis by using the software packages HistCite and VosViewer. The results of our analyses display a profound theoretical foundation of SCI embedded in a clearly defined theoretical field driven by the dynamic capability, relational as well as resource-based view. SCI research is further driven by empirical-quantitative research looking at the effects of SCI on firm performance.

Keywords: Supply chain integration · Foundation · Citation analysis · Co-citation analysis

1 Introduction

1.1 Starting Points of Consideration

Supply Chain Management (SCM) refers to the internal and external integration of business processes in order to increase customer value (e.g. Frohlich and Westbrook 2001) and becomes therefore important since competition changed from company against company to company's network against another company's network (see Kotzab et al. 2015). This integration of business processes goes in a forward direction (downstream to customers) as well as into a reverse direction (upstream to suppliers) with the aim to optimize a whole entity instead of a single part of the chain (Cooper et al. 1997; Cooper and Ellram 1993; Heikkilä 2002). Overall, the construct of integration plays a major role in the whole SCM-discussion as Mouritsen et al. (2003) already pinpointed by identifying SCI as the key prerequisite of SCM. This is supported by Frohlich and Westbrook (2001) who refer to the strategic importance of SCI by highlighting the value of integrating suppliers, manufacturers and customers.

1.2 Research Objectives and Methodology

In order to be successful in a business environment that has been changed by globalization and digitalization, value creation processes must be considered beyond the respective company boundaries and analyzed in their entirety. This requires the integration of the business processes of all participants in a supply chain (SC)

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(Lee et al. 2004). However, this requires the integration and coordination of the various actors (Li et al. 2009). So far, a lot of research (e.g. Fabbe-Costes and Jahre 2008; Flynn et al. 2010; Gimenez et al. 2012; Leuschner et al. 2013; Prajogo and Olhager 2012; Wong et al. 2011) examined the impact of SCI on performance (of the firm) and identify thereby a positive relationship between these two variables. On the contrary research concludes, that there is lack of clear evidence and inconclusive results whether SCI improves SC performance (Chavez et al. 2015; Fabbe-Costes and Jahre 2007).

However, the goal of this paper is to go into depth with the construct of SCI by identifying and mapping the intellectual foundation of SCI research domain. Thereby, we diagnose the most influential works, portray their interrelationships and reveal citation clusters/themes which research regularly draws upon (e.g. White and McCain 1998). For doing this, we collected and analyzed data from the Web of Science Core Collection (for a detailed description of the search methodology see Table 1).

Table 1. Search Methodology

Refinement step	Results
1. Search TOPIC (= in title, abstract and author supplied keyword) "supply chain integration" in Web of Science Core Collection (no time limitation)	7.506
2. Refined by Web of Science Categories: "Management" OR "Business" OR "Economics" OR "Operations Research Management Science"	4.065
3. Refined by Document Type: "ARTICLE"	2.967
4. Refined by Source Titles: Select only Journals with 2 Star ABS Journal Rating or higher OR 2nd best score or higher in at least 9 out of the 12 rankings in the Harzing list (38 Journals – see Appendix 1)	1.717

We used the latest Harzing List (Harzing 2019) as well as the 2018 ABS Journal Guide for selecting our relevant journals (Chartered Association of Business Schools 2018). Thereby we used only those journals of the ABS categories "Operations and Technology Management" and "Operations Research and Management Science" which have at least a 2-star rating result or those which have the 2nd best score or higher in at least 9 out of the 12 rankings in the Harzing list.

The final data set consists of 1.717 articles by more than 3.000 authors. This sample includes more than 53.000 cited references which were further examined with two bibliometric software tools namely HistCite (Garfield 2009a) and VOSviewer (Eck and Waltman 2010) in order to receive both, analytical as well as visualized results for citation and co-citation analyses.

The remainder of the paper is as follows. After introducing the research objective and the general methodological considerations, chapter 2 presents the theoretical as well as practical importance and aspects of SCI. Thereafter we document in chapter 3

the results of our bibliometric analyses and identify the roots and intellectual foundation of SCI. The paper closes with a discussion of our findings following a statement about theoretical consequences for the SCI community and an outlook for future research.

2 What is Supply Chain Integration?

SCI is defined as the degree to which a supply chain actor enters into strategic cooperation with other supply chain actors and to what extent they control inter- and intra-organizational processes in a collaborative manner (Jayaram et al. 2010; Schoenherr and Swink 2012; Wiengarten et al. 2016). The aim is thereby to achieve the most effective and efficient flow of products, information and finance, so that maximum added value is offered to the end customer (Flynn et al. 2010). Obviously, SCI concepts consider the flow of materials and information along a value chain. Ideally, the boundaries between the activities of the respective organizations should flow smoothly into each other and no longer be separated for specific organizations.

As already mentioned, there are two directions of integration, forward integration of physical flows of goods from suppliers to customers and backward integration of the data flow from customers to suppliers (Prajogo and Olhager 2012). Furthermore, SCI can be divided into internal and external integration where internal integration is based on the consolidation and synchronization of internal company processes and external integration refers to the cross-company merging of inter-organizational strategies and processes (Flynn et al. 2010). In order to achieve an optimal level of SC integration the following six different dimensions have to be considered (Stank et al. 2001): customer service, internal integration, material and service supplier, technology and planning, measurement and relationship.

Another distinction in SCI is given by Mouritsen et al. (2003) who differ between information integration and organizational integration. A high degree of informational SCI is characterized by increased logistics-related communication between the individual actors as well as improved coordination of an organization's logistics activities between suppliers and customers (Schoenherr and Swink 2012). On the one hand, a high degree of information integration can achieve a variety of benefits. These can be reduced product or service costs, the creation of a sustainable competitive advantage, reduced complexity, reduced lead times and increased flexibility in production and delivery. In addition, higher reliability, better inventory management and a better understanding of the end customer's needs can be achieved (Korpela et al. 2017; Stank et al. 2001). This allows manufacturers to respond more flexibly to individual customer needs, delivery times can be shortened and inventory can be minimized, which contributes significantly to the efficiency of a SC. On the other hand, a low degree of

information integration leads to the so-called bullwhip effect, which has been widely discussed for several years (Lee et al. 1997).

Since it is not feasible for companies alone to establish end-to-end information integration along the SC, companies must establish collaborative relationships. The advantages of SC integration with the help of digital technologies results in reduction of transaction cost due to less inter- and intra-corporate exchange (Korpela et al. 2017). The exchange of information using IT systems makes it possible to disseminate more information within a shorter time (Prajogo and Olhager 2012).

In order to achieve an increase in the overall performance, companies should therefore focus on information integration. This is achieved by sharing critical information, both strategically and operationally, within a SC network by means of IT (Prajogo and Olhager 2012). For an effective integration of business processes, it is essential to share, for example, tracking data or customer demand information electronically between organizations along the SC.

The organizational integration is therefore important as the supply chain is considered to be a whole entity and decision-making is not carried out from an individual supply chain actor's point of view but from the whole supply chain perspective (see e.g. Cooper et al. 1997). Successful organizational integration requires a high degree of mutual trust between the supply chain actors (see e.g. Skjoett-Larsen 2000). Overall, organizational integration is seen as the facilitator of sharing activities between the members of a supply chain (Mouritsen et al. 2003).

Taking all these aspects into account, we consider SCI as an accepted research domain or area within the field of SCM which allows to further examine the roots of this particular domain.

3 Results

Since 1995, more than 1,700 SCI-specific papers were published in the 38 journals, that we examined. Since 2010, more than 100 papers (except in 2012 and so far in 2019) were annually issued.

The most productive authors (in terms of number of publications) are Zhao XD (28 papers), Huo BF (23 papers), Gunasekaran (18 papers), Jayaram (16 papers) and Wong CWY (15 papers). The most important institutions in terms of number of publications are Michigan State University (57 papers), Hong Kong Polytech University (52 papers), Arizona State University (32 papers) as well as Politecnio Milano and Zheijiang University (with each 28 papers).

In Fig. 1 we can see the historiography of the citation relations of the 30 most cited papers of our sample based on the local citation score (LCS = Number of citations to the paper from within the collection; see Garfield (2009b)) as identified by the HistCite software (see also Appendix 2). The publication years of these papers span from 1997 to 2012 and their citation relations show 30 nodes with 95 links with a minimum citation count of 41 and a maximum of 345.

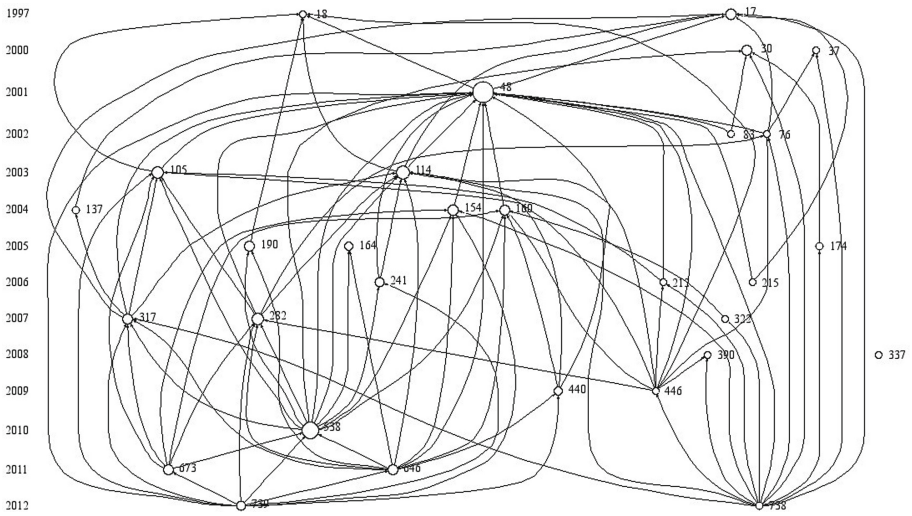

Fig. 1. Citation relations of the 30 most cited CCC papers as indicated by HistCite

Overall, nearly all papers represent kind of two citation networks, where Frohlich and Westbrook (2001) is the connector. There is one isolated reference (Carter and Rogers 2008) that presents a framework for sustainable SCM, while the remaining 29 papers deal either with particular SCI aspects on operational or overall performance of a firm or with SCM/Logistics issues.

Figures 2 and 3 present the results of a co-citation analysis for references and for sources as identified by the VOSviewer software tool. The distances between the respective objects in both figures relate to the similarity of the objects (Eck 2011). We are able to identify in both cases three clusters. The first cluster 'Methodology/Theory' refers to 11 red-dotted publications at the right side of Fig. 2 and includes solely papers in regards to processing quantitative empirical research (e.g. structural equation modeling) and ensuring valid results as well as papers representing a clear theoretical position, here dynamic capabilities, relational view as well as the resource-based view (Barney 1991; Dyer and Singh 1998; Teece et al. 1997).

The second cluster 'SCM/SCI' (11 green dotted, left side of Fig. 2) represents papers rather dealing with general aspects of SCI as well as with supplier integration, supply chain collaboration and the bullwhip effect. It also includes one methodological paper related to case study research. The third cluster 'SCI-Performance linkage' (8 blue dotted, upper part of Fig. 2) includes mainly papers which deal with the examination on the effects of SCI on performance.

The majority of the papers in clusters 2 and 3 stem from the Journal of Operations Management being one of the most prestigious journals in the area. Interestingly enough we are able to identify direct citation linkages between all clusters, which can also be verified by the co-citation patterns of the 30 most cited journal outlets (see Fig. 3).

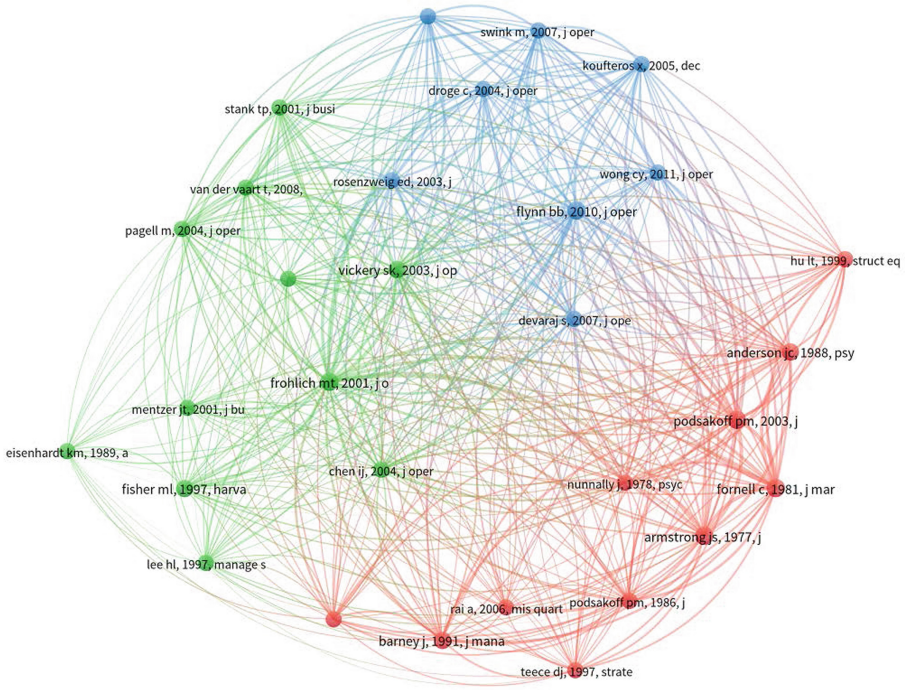

Fig. 2. Network of the 30 most co-cited articles (see also Table 2)

Table 2. 30 most co-cited papers (alphabetical order)

Red Cluster 1: 'Methodology'	Anderson and Gerbing (1988); Armstrong and Overton (1977); Barney (1991); Dyer and Singh (1998); Fornell and Larcker (1981); Hu and Bentler (1999); Nunnally (1978); Podsakoff et al. (2003); Podsakoff and Organ (1986); Rai et al. (2006); Teece et al. (1997)
Green Cluster 2: 'SCM-SCI'	Chen and Paulraj (2004); Eisenhardt (1989); Fisher (1997); Frohlich and Westbrook (2001); Lee et al. (1997); Pagell (2004); Petersen et al. (2005); van der Vaart and van Donk (2008); Vickery et al. (2003); Mentzer et al. (2001); Stank et al. (2001)
Blue Cluster 3: 'SCI-Performance'	Devaraj et al. (2007); Droge et al. (2004); Flynn et al. (2010); Koufteros et al. (2005); Narasimhan and Kim (2002); Rosenzweig et al. (2003); Swink et al. (2007); Wong et al. (2011)

Also, here we see three interlinked journal clusters out of which one contains more than half of the journals (17) and is consequently larger than the two others (representing 9 and 4 journals). The red dotted cluster at the left side of Fig. 3 stands for management journals including marketing, information systems, product innovation, organization, strategic management as well as operations management journals.

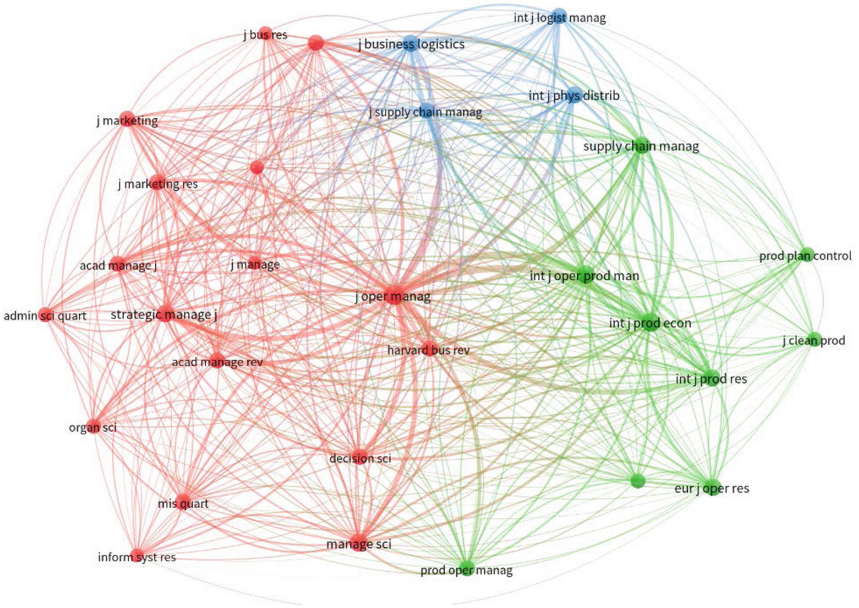

Fig. 3. Network of the 30 most co-cited publication outlets (see also Table 3)

Table 3. 30 most co-cited journals (alphabetical order)

Red Cluster 'Management oriented SCI'	Academy of Management Journal; Academy of Management Review; Administrative Science Quarterly; Decision Science; Harvard Business Review; Industrial Marketing Management; Information Systems Research; Journal of Business Research; Journal of Management; Journal of Marketing Research; Journal of Marketing; Journal of Operations Management; Journal of Production & Innovation Management; Management Science; MIS Quarterly; Organisation Science; Strategic Management Journal
Green Cluster 'Production-SCI'	European Journal of Operational Research; International Journal of Production & Operations Management; International Journal of Production Economics; International Journal of Production Research; Journal of Cleaner Production Omega; Production and Operations Management; Production Planning and Control; Supply Chain Management: An International Journal; International Journal of Operations & Production Management
Blue Cluster 'Logistics/SCM-SCI'	International Journal of Physical Distribution & Logistics Management; International Journal of Logistics Management; Journal of Business Logistics; Journal of Supply Chain Management

The strongest journal here is represented by the Journal of Operations Management. Opposite to this cluster on the right side of Fig. 3 (green dotted journals) are production planning, operations research and production economics journals representing the manufacturing/production perspective of integration. Interestingly enough it contains also one more SCM-specific journal. The four journals (blue dotted) in the upper part of Fig. 3 represent the leading logistics/SCM-specific journals.

4 Discussion and Conclusion

The most influential work for the domain of SCI is the work by Frohlich and Westbrook (2001; citation count of 345) who basically started the discussion on SCI. The next 11 papers though refer to the theoretical as well as methodological foundation of the SCI research domain, which is clearly characterized as being quantitative-empirical. The theoretical fundament of SCI research is found in the resource-based, relational and dynamic capabilities view of the organization. This means that the overall foundation of SCI is found inside the firm which is looking for the adequate external setting for successfully integrate upstream and downstream. The dominating research question relates to the examination of the effects of SCI on the performance of the firm or a specific firm function.

Researchers in the field of SCI use mainly the Journal of Operations Management as their knowledge hub, followed by the International Journal of Production Economics, the International Journal of Production and Operations Management and Management Science which all represent a clear Operations Management view. The first logistics/SCM-specific journal comes with Supply Chain Management: An International Journal. However, the domain of SCI has a broad journal fundament from the leading academic management journals as well as leading specific area journals.

Our findings offer several positive consequences for the scientific SCI community: The results can confirm, contradict or even suggest notions for beginners or experts in the field of SCI by providing the intellectual foundation in terms of authors, papers, journals and thematical citation clusters of SCI research. Thus, one can easily distinguish, relate and prioritize findings in literature research. Furthermore, our paper provides insight into the relevant SCI research communities by providing a list of appropriate journals.

As bibliometric analyses are built upon available data as well as the constraints by the authors' literature search, our paper has some limitations. First, even though we eliminated typos and other errors (e.g. different journal labels for the same journal) and improved the data quality of the data set, it cannot be concluded that the elimination of every possible typographical difference or mistake was achieved. Although, different available automatic algorithmic based correction packages (e.g. algorithms provided by "OpenRefine" or "VOSviewer") were used, some citations still had to be corrected and equalized manually. Second, due to the nature of quantitative analyses, like bibliometric analysis, simplification and generalization is achieved, in most cases, at the expense of information preciseness. Beside the possibility to measure the relatedness of papers on the basis of the co-citations, as we did, it is also possible to measure the relatedness of papers on the basis of the number of words that occur in both documents. Second approach might reveal further insight in the field of SCI. This could be subject to future research.

Appendix 1

Included Journals based on Harzing Quality List (2019) and Academic Journal Guide (2018)

No.	Source title (sorted in alphabetical order)
1	Annals of Operations Research
2	Business Process Management Journal
3	Computers Operations Research
4	Decision Sciences
5	European Journal of Industrial Engineering
6	European Journal of Operational Research
7	IEEE Transactions on Engineering Management
8	Industrial and Corporate Change
9	Industrial Marketing Management
10	Information Management
11	Information Systems Research
12	Interfaces
13	International Journal of Computer Integrated Manufacturing
14	International Journal of Electronic Commerce
15	International Journal of Operations Production Management
16	International Journal of Physical Distribution Logistics Management
17	International Journal of Production Economics
18	International Journal of Production Research
19	International Journal of Quality Reliability Management
20	International Journal of Technology Management
21	Journal of Business Logistics
22	Journal of Business Research
23	Journal of Management Information Systems
24	Journal of Operations Management
25	Journal of Product Innovation Management
26	Journal of Purchasing and Supply Management
27	Journal of Strategic Information Systems
28	Journal of Supply Chain Management
29	Journal of the Operational Research Society
30	Management Science
31	Manufacturing Service Operations Management
32	Omega International Journal of Management Science
33	Production and Operations Management
34	Production Planning Control
35	Research Policy
36	Strategic Management Journal
37	Supply Chain Management an International Journal
38	Total Quality Management Business Excellence

Appendix 2

30 most cited papers based on the local citation score (LCS)

Nodes: 30, Links: 95
LCS, top 30; Min: 41, Max: 345 (LCS scaled)

		LCS	GCS
1.	17 Lee HL, 1997, MANAGE SCI, V43, P546	113	1893
2.	18 Ragatz GL, 1997, J PROD INNOVAT MANAG, V14, P190	45	410
3.	30 Lambert DM, 2000, IND MARKET MANAG, V29, P65	90	988
4.	37 Stock GN, 2000, J OPER MANAG, V18, P531	45	224
5.	48 Frohlich MT, 2001, J OPER MANAG, V19, P185	345	992
6.	76 Frohlich MT, 2002, DECISION SCI, V33, P537	48	191
7.	83 Ho DCK, 2002, INT J PROD RES, V40, P4415	41	134
8.	105 Rosenzweig ED, 2003, J OPER MANAG, V21, P437	126	404
9.	114 Vickery SK, 2003, J OPER MANAG, V21, P523	160	534
10.	137 Kulp SC, 2004, MANAGE SCI, V50, P431	61	332
11.	154 Pagell M, 2004, J OPER MANAG, V22, P459	113	349
12.	160 Droge C, 2004, J OPER MANAG, V22, P557	97	289
13.	164 Gimenez C, 2005, INT J OPER PROD MAN, V25, P20	72	184
14.	174 Power D, 2005, SUPPLY CHAIN MANAG, V10, P252	62	254
15.	190 Petersen KJ, 2005, J OPER MANAG, V23, P371	96	516
16.	212 Cagliano R, 2006, INT J OPER PROD MAN, V26, P282	52	138
17.	215 Vachon S, 2006, INT J OPER PROD MAN, V26, P795	52	552
18.	241 Cousins PD, 2006, J OPER MANAG, V24, P604	79	269
19.	282 Swink M, 2007, J OPER MANAG, V25, P148	122	331
20.	317 Devaraj S, 2007, J OPER MANAG, V25, P1199	100	298
21.	322 Zhou H, 2007, J OPER MANAG, V25, P1348	50	301
22.	337 Carter CR, 2008, INT J PHYS DISTR LOG, V38, P360	43	1033
23.	390 Swafford PM, 2008, INT J PROD ECON, V116, P288	44	213
24.	440 Braunscheidel MJ, 2009, J OPER MANAG, V27, P119	73	352
25.	446 Kim SW, 2009, INT J PROD ECON, V119, P328	43	136
26.	538 Flynn BB, 2010, J OPER MANAG, V28, P58	232	824
27.	646 Zhao XD, 2011, J OPER MANAG, V29, P17	90	246
28.	673 Wong CY, 2011, J OPER MANAG, V29, P604	100	302
29.	738 Prajogo D, 2012, INT J PROD ECON, V135, P514	59	289
30.	739 Schoenherr T, 2012, J OPER MANAG, V30, P99	84	174

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