The use of social network analysis in operations and supply chain management: A systematic literature review

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Abstract

Understanding of supply chains is transforming from a linear interaction of different operating functions to a network-based ecosystem. Social network analysis (SNA) as a powerful methodology to study patterns of inter-firm behaviours and relationships, though has been widely adopted in different research areas, how to design research using SNA for operations and supply chain management research has remained a gap that this paper seeks to address. This paper offers contributions to SNA research design derived from a systematic literature review of relevant studies.

Keywords: systematic literature review, social network analysis, supply chain management

Introduction

In the past decade, studies focused on networks and relationships within operations and supply chain management have been increased significantly (Wichmann and Kaufmann, 2016). Given that the understanding of supply chains is transforming from a linear interaction of different operating functions to a network-based ecosystem, traditional views fails to capture the complexity needed to understand an individual firm's behaviour and strategy, as both are dependent on a larger supply network that the firm embedded in (Choi and Kim, 2008; Kim et al., 2011; Sloane and O'Reilly, 2012). Social network analysis (SNA), a '*structural analysis*' (Knoke and Kuklinski, 1986), is a powerful methodology for describing and analysing the connections of actors and ties within a network (Carter et al., 2007). The actors represent various entities such as individuals, companies, countries, etc. Ties represent the different relationships between actors, such as trust, friendship, cooperation and competition (Butts, 2008; Borgatti and Li, 2009). SNA not only offers the mapping of these relationships, but also the network structure arises from these linkages (Scott, 2000; Sloane and O'Reilly, 2012). Since the level of analysis could be an individual, a company or even a network; fashioning

the structure enables managers to analyse the role of an individual or company and how their structural position is embedded in its supply network and thus be better equipped to facilitate knowledge transfer and access to resources (Carter et al., 2007; Bellamy et al., 2014; Gao et al., 2015).

Since the 1970s, the SNA approach is widely adopted by different research areas, ranging from sociology, anthropology to management studies and economics, etc. (Borgatti and Foster, 2003; Sloane and O'Reilly, 2012). Since the 1990s, SNA has received increased interest in the operations and supply chain management field (Galaskiewicz, 2011). Supply chains have both 'hard' and 'soft' ties (Borgatti and Li, 2009). As organisations increasingly compete based on their ability to manage their 'soft' ties, managers have found that these informal networks are hard to observe and manage (Carter et al., 2007); whereas SNA works well with this soft side, helping to understand how personal relationships, diffusion of knowledge translates into competitive advantage for a company (Wichmann and Kaufmann, 2016).

Though the potential of SNA is widely recognised across multiple disciplines, there are still several contextual and methodological challenges that are associated with the use of this method in the operations and SCM field (Galaskiewicz, 2011; Wichmann and Kaufmann, 2016). Defining network boundaries and capturing inter-relationships have long been a critical challenge (Provan and Sebastian, 1998), resulting in data collection difficulties for social network bounding (Butts, 2008; Sloane and O'Reilly, 2012). In addition, during SNA data collection it is problematic to guarantee respondents' anonymity as most data collection techniques would; thus, potential participants tend to be reluctant to take part (Borgatti and Molina, 2003).

Three literature reviews, namely, (Borgatti and Li, 2009; Galaskiewicz, 2011; Wichmann and Kaufmann, 2016) covering an overview of SNA theory and its adaptations in the broad discipline of SCM have been conducted to-date. Key insights from the three articles are provided in Table 1. Although all of them address the importance of SNA and its potential role in operations and supply chain management research; none of these reviews clearly linked SNA to research design i.e. to what extent and how should SNA theory must be implied. Such an investigation is timely, because of the rapid progressing level of interest in operations and SCM discipline and the challenges on hold to be solved.

Table 1- A summary of previous literature reviews

Reference	Research Methodology	Application to OM/ SCM	Relevance and Gap
(Borgatti and Li, 2009)	Narrative literature review	Investigation of feasibility of embedding key SNA theories to SCM context. including - Nodes and ties - Egonet Composition	A starting point to confirm the possibility of applying major SNA concepts into supply networks, both whole and ego networks, together with intermediate networks.

		• Structural Holes • Node Centrality • Cohesive Subgroups • Equivalence • Whole Network Properties • Bipartite Graphs	However, what to investigate and how to apply SNA is not clearly specified.
(Galaskiewicz, 2011)	Narrative literature review	Investigation of particular relevance of social network theory to SCM research. Define which SCM problems are especially fruitful to study from a network perspective.	A general idea of when and how could social network perspective be possibly adopted in the SCM field. A brief suggestion of dynamic network visualisation programs was made. However, when and where to use visualisation programs were not identified.
(Wichmann and Kaufmann, 2016)	Systematic literature review	Investigation of when and how SNA used to the SCM field.	Only defines which SNA theory is adopted but does not represent to which extent the SNA theory is applied to the SCM discipline.

Therefore, this study aims to systematically review the literature on social network analysis in operations and supply chain management and answer the following research questions:

- *What to investigate using SNA in operations and SCM research?*
- *How is SNA applied in operations and SCM research?*
- *To what extent is SNA applied on operations and SCM research?*

This remainder of this paper is structured as follows. The next section explains the research design and the methodology, followed by an analysis of the selected literature and discussion of the descriptive and thematic findings. The last section presents the contribution of this review and future research implications.

Research design
To answer the research questions, this study examines the usage of SNA in operations and SCM by following a systematic literature review (SLR) approach. Usage here meaning that a study either adopted SNA as part of its theoretical framework or that a study used SNA as its research method. Unlike narrative literature reviews, SLR is a transparent and evidence-based approach conducted by adopting a rigorous, replicable and scientific process (Tranfield et al., 2003). Benefiting from the clear structure from Tranfield et al. (2003) and key elements adapted from methodology provided by (Denyer and Tranfield, 2009; Durach et al., 2015; Zimmermann et al., 2016; Ali et al., 2017), this study conducts an SLR by following three main steps: (1) locating studies (2) study selection and evaluation (3) study analysis and synthesis.

Locating studies
The first step in this review is to locate and identify appropriate literature. To identify key literature, our search was limited to the peer-reviewed journal articles published in English between January 2002 and December 2017. Articles were included when they clearly discussed SNA as part of their theoretical building or was used a methodology for empirical OM/SCM phenomena. In contrast, exclusion criteria included grey literature such as books, magazines, conference papers, white papers, etc. Literature reviews and papers adopted SNA as a methodology but did not apply to empirical OM/ SCM phenomena were also excluded. A summary of the inclusion and exclusion criteria is listed in Table 3.

To search for studies two categories of keywords were defined:

Table 2- Key words

Words related to supply chain	*'Supply chain', 'SCM', 'operations', 'supply'*
Words related to social network analysis	*'Social network analysis', 'SNA', 'social network theory'*

To obtain a wider range of literature, two electronic databases *SCOPUS* and *Google Scholar* were searched. According to (Mustafa Kamal and Irani, 2014), *SCOPUS* is the biggest database for journal articles and conference proceedings. The application of SNA research designs in operations and SCM disciplines is relatively recent and for that reason, we choose *Google Scholar* rather than *Web of Science* to complement searching for relevant literature due to its wider database (Ben-Daya et al., 2017). The search was based on possible combinations of the two groups of keywords, using the title, abstract and keyword search. Identification of keywords, search strings were then applied to the two selected databases for the past 15 years giving a total result of 1320 records.

Following previous SLRs in SCM research, articles from top-ranked, operations and SCM discipline-specific academic journals were selected (Giunipero et al., 2008; Mustafa Kamel and Irani, 2014). This study considered the following journals: *Journal of Operations Management (JOM), International Journal of Operations and Production Management (IJOPM), Production and Operations Management (POM). International Journal of Production Economics (IJPE), International Journal of Production Research (IJPR), Journal of Supply Chain Management (JSCM), Production Planning and Control (PPC), Supply Chain Management: An International Journal (SCMIJ), International Journal of Physical Distribution and Logistics Management (IJPDLM), Journal of Business Logistics (JBL),*

Journal of Purchasing and Supply Management (JPSM). After locating the articles and removing the duplicates, 64 articles were included for further full-text evaluation.

Study selection and evaluation
Figure 1 presents the selection process of this review, the number of included and excluded articles are documented for repeatability. After the first search stage, the titles and articles were recorded into an electronic datasheet and the abstracts were read, after which articles were reviewed and selected based on their use of SNA in research design. By doing so, 38 articles were included for further review processes.
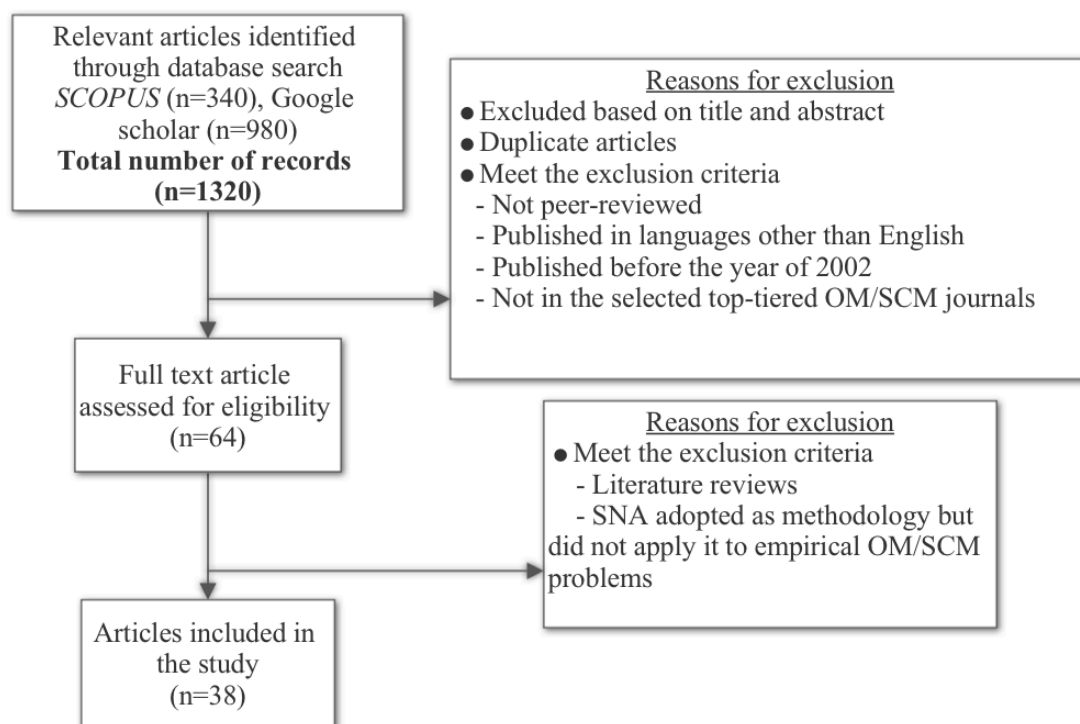


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┌─────────────────────────┐
│ Relevant articles       │     ┌──────────────────────────────────────────┐
│ identified through      │     │         Reasons for exclusion              │
│ database search         │     │ ● Excluded based on title and abstract     │
│ SCOPUS (n=340), Google  │     │ ● Duplicate articles                       │
│ scholar (n=980)         │────▶│ ● Meet the exclusion criteria              │
│ Total number of records │     │   - Not peer-reviewed                      │
│ (n=1320)                │     │   - Published in languages other than      │
└─────────────────────────┘     │     English                                │
            │                   │   - Published before the year of 2002      │
            ▼                   │   - Not in the selected top-tiered OM/SCM  │
┌─────────────────────────┐     │     journals                               │
│ Full text article       │     └──────────────────────────────────────────┘
│ assessed for            │
│ eligibility             │     ┌──────────────────────────────────────────┐
│ (n=64)                  │     │         Reasons for exclusion              │
└─────────────────────────┘     │ ● Meet the exclusion criteria              │
            │            ───────▶│   - Literature reviews                     │
            ▼                   │   - SNA adopted as methodology but         │
┌─────────────────────────┐     │ did not apply it to empirical OM/SCM       │
│ Articles included in    │     │ problems                                   │
│ the study               │     └──────────────────────────────────────────┘
│ (n=38)                  │
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Figure 1- Article selection process

Table 3- Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Adopted as a methodology to analyse certain OM/ SCM phenomena • Did not employ SNA as a methodology but social network	• Literature reviews of SNA • Adopted as a methodology but did not apply it to empirical OM/ SCM phenomena • Conference papers, proceedings, etc.

perspective was adopted to derive
new propositions
- Did not employ SNA as a
methodology but social network
perspective was part of the
theoretical framework building to
investigate certain OM/ SCM
phenomena

Study analysis and synthesis

According to Denyer and Tranfield (2009), the goal of the analysis is to examine and dissect the individual studies and identify their relationship; while the goal of synthesis is to group the result of the studies into a different arrangement to explore and develop the knowledge that is not apparent from reading the individual studies. Since the objective of this review is **to explore what is investigated, how and to what is extent SNA is adopted in the research design in OM & SCM discipline**, the selected studies were synthesized into ten dimensions in order to answer the three questions. The breakdown of the synthesis is presented in Figure 2 and discussed in the following two sections.
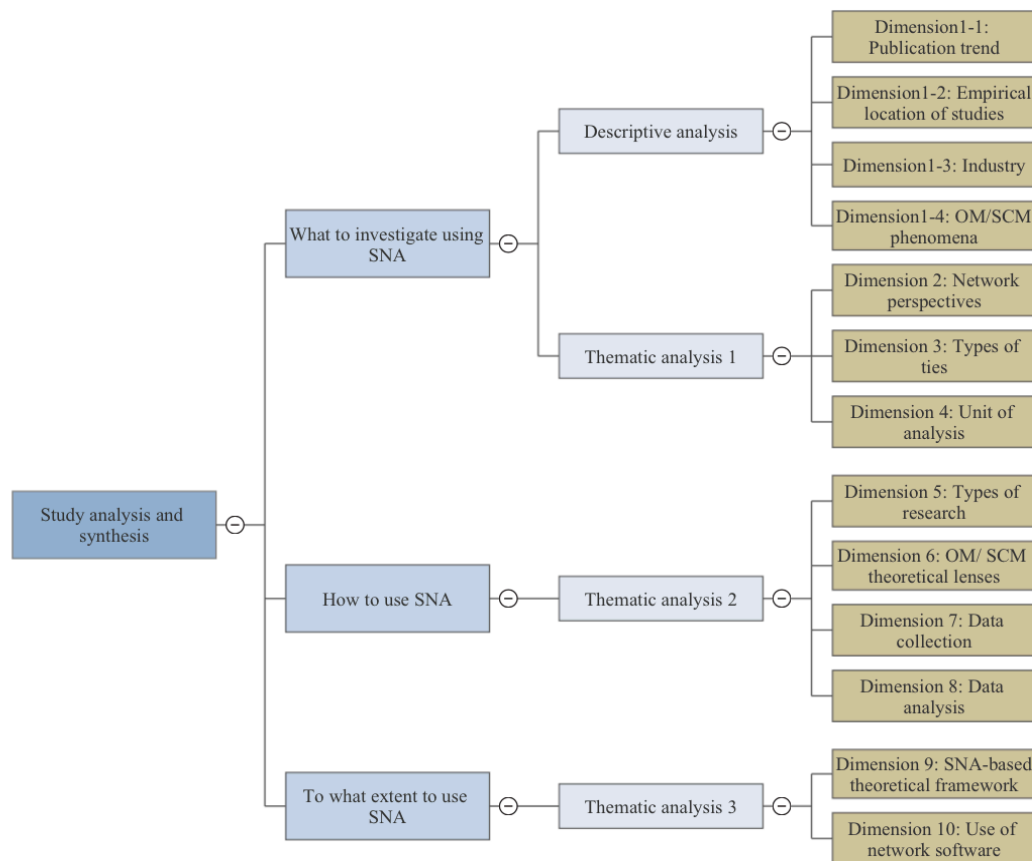

Figure 2- Study analysis and synthesis

Descriptive results

The aim of this section is to provide descriptive statistics on the context of the selected literature regarding the relationship between OM/SCM phenomena and the usage of SNA theory. It provides a quantitative analysis of the selected papers and demonstrated answers to 'what to investigate using SNA in OM/SCM studies' subsection. Four dimensions will be descriptively analysed, respectively publication trend, the empirical location of studies, industry and OM/SCM phenomena.

Thematic results

The aim of this section is to produce qualitative analysis on the adoption of SNA in the research design of selected articles in an aggregative and interpretative way (Tranfield et al., 2003). Drawn from extant conceptual works in SNA research (Borgatti and Foster, 2003; Stephen P. Borgatti and Li, 2009; Galaskiewicz, 2011), three general aspects of thematic analysis were conducted in order to answer *what to investigate, how and to what extent* SNA was used. Key results are presented in table 4.

Table 4- Summary of thematic results

Dimensions/ Typologies	No. of papers used in total	Percentages
Network perspectives		
Dyad	8	23%
Triad	5	14%
Ego network	9	26%
Entire network	13	52%
Types of network ties		
Continuous		
• Similarities	10	25%
• Social relations	5	20%
Discrete		
• Interactions	6	24%
• Flows	4	16%
Unit of analysis		
Individual level	3	9%
Inter-firm level	30	86%
Intra-firm level	2	6%
Types of research		
Conceptual	25	66%
Empirical	13	34%
OM/SCM theoretical lens		

Resource-based view (RBV)	5	18%
Transactional Cost Economics (TCE)	3	11%
Network theory	9	32%
Game theory	1	3%
Complexity theory	3	11%
Contingency theory	1	3%
Information processing theory	1	3%
Social contract	1	3%
Institutional theory	1	3%
Influence behaviour theory	1	3%
Information overload theory	1	3%
Intra-organisational influence theory	1	3%
Graph theory	1	3%
Data collection		
Questionnaire/ Structured interview	6	43%
Electronic sources and the Internet	8	57%
Data analysis		
Node level		
• degree centrality	5	19%
• closeness centrality	6	23%
• betweenness centrality	7	27%
Network level		
• network centralization	4	15%
• network density	4	15%
• network complexity	0	
SNA-based theoretical framework		
Strength of ties		
Social capital	5	14%
• structural capital	8	22%
• relational capital	14	38%
• cognitive capital	2	4%
• Structural hole	6	16%
• Network exchange	1	3%
• Social exchange theory	1	3%
Use of software		
UCINET	12	32%
PAJEK	1	3%
NETMINER	1	3%
N/A	24	62%

Discussion and implications

The descriptive findings of this study reveal that there is a growing interest in applying SNA in OM/SCM research, especially for manufacturing related industries. The most investigated phenomena are inter-organisational relationships such as buyer-supplier relationships and relational performance. In addition, recent work has been 'on-trend' in using SNA to address new product development, supply chain innovation and sustainability.

The review makes three contributions to future SNA research. Firstly, by offering a platform and research agenda for further SNA work and research design. Secondly, in identifying two different approaches in current SNA research. The first focuses mostly on theoretical propositions for entire network studies (Sloane and O'Reilly, 2012), The second approach is empirical research on smaller elements of the network such as dyads, triads and ego networks (Wasserman and Faust, 1994; Choi and Wu, 2009; Borgatti and Halogen, 2011). Adding these two distinct approaches together still enables this study to identify a gap in extant literature - empirical research using the entire network perspective. This observation is undoubtedly related in part at least to the issues and limitations of conducting SNA research this review has identified. In particular, during network data collection procedures, scholars should be highly aware of data anonymity (Borgatti and Molina, 2003), validity (Peng et al., 2010) and boundary specification issues (Sloane and O'Reilly, 2012) that are raised by trying to research networks or parts thereof. A very promising opportunity here that the review identifies, is the development and use of SNA-based network visualisation software (Scott, 2000).

The review identified a strong focus on manufacturing networks as the context for SNA related OM and supply chain research. This bias may also explain, in the context of SNA and strong/weak ties theory another bias (Granovetter, 1973). This study found that extant work using strong/weak ties is strongly biased to strong and continuous ties, such as those found in high volume, repetitive supply chain environments such as automotive, electronics and manufacturing generally. There is a need for work which explores more project based, discontinuous/ weak inter organisational ties. The roles of weak ties as bridging knowledge transfer are hardly addressed to-date in extant literature and here there is a link to the issue of power. The research identified a spike in SNA use in OM and SCM driven by a special issue focused on power and another gap seems to be on how power is addressed in relationships founded on weak and discontinuous ties i.e. not high volume manufacturing networks. Finally, the most distinguishing feature of SNA theory is the focus on relationships (Wasserman and Faust, 1994). Based on this, related OM/SCM theories investigating relationships have an opportunity to draw upon SNA theory in research design. Transaction Cost Economics (Gulati and Singh, 1998) and Complexity theory (Choi et al., 2001) would be two such theories already used in OM and SCM research.

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