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Social network analysis in operations and supply chain management: A review and revised research agenda

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Purpose:

Social network analysis (SNA) seeks to manage the connections between entities through investigating and understanding behaviours and relationships. This study demonstrates the increasing relevance of social network approaches to solving contemporary and looming Operations Management (OM) and Supply Chain Management (SCM) problems; including the coordination operations challenges raised by increased connectivity.

Research design/methodology:

The systematic literature review approach adopted here examines 63 papers in OM and SCM published between 2000 and 2019. To-date OM reviews on SNA have focused on discussing archetypal supply chains, what differentiates this study is the focus on how value was created in other forms of chains and operations.

Findings:

This study reveals that current SNA adoption in OM is dominated by a manufacturing style focus on linear, sequential value creation; with a resulting focus only on sequential interdependence. SNA studies on reciprocally co-ordinated value creation (e.g. many service and network operations) are shown to have been neglected and are linked to a new agenda on contemporary management issues.

Research implications:

Beyond encouraging the use of SNA, this study seeks to re-orient SNA approaches towards how contemporary services and networks create value.

Originality/value:

Through adopting a unique combination of approaches and frameworks, the study challenges extant work to offer a substantially revised agenda for SNA use in Operations and Supply Chain Management.

Keywords:

Social Network Analysis, Social Network theory, Systematic Literature Review, Operations Management, Supply Chain Management

Paper type:

Literature review

1. Introduction

Grounded in Porter (1985) supply chain transactions are conducted by sequential interdependent parties where value is primarily created by transforming inputs into outputs from upstream to the downstream supply chain (Christopher, 1998). While this linear perspective is helpful for planning transaction routines for product/service inspection, production and delivery (Kim *et al.*, 2011; Sloane and O'Reilly, 2013), it does not cover all operations management value creating activities. For example, it fails to capture the complex impacts from human factors involved within internal SC streams (Gligor and Autry, 2012), as well as external, indirect value-adding interdependences such as supplier's innovation networks (Choi and Kim, 2008) and the unique nonlinear value sources of specialist service networks (Lazzarini *et al*., 2001).

Social network analysis (SNA), a '*structural analysis'* (Knoke and Kuklinski, 1986), is a powerful paradigm 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. Whereas, ties represent the different relationships between actors, such as trust, friendship, cooperation and competition (Butts, 2008; Borgatti and Li, 2009). SNA offers not only the mapping of these relationships, but also visualises the network structure that arises from these linkages (Scott, 2000; Sloane and O'Reilly, 2013). Since the level of analysis could be an individual, a company or even an entire network; shaping 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).

The SNA approach did not evolve in a neat, linear process. It came about through three distinct disciplines (psychology, anthropology and mathematics) meeting in the 1930s (Prell, 2012). Most notably, the field of 'sociometry' developed from Moreno and Jennings (1934) is widely considered the precursor to SNA (Prell, 2012). Sociometry drove the development of graph theory (Holland and Leinhardt, 1977), and graph theory remains the basis of most SNA measurement techniques (Haythornthwaite, 1996; Kim *et al.*, 2011). To evaluate the structural characteristics of supply networks, researchers have suggested many analytical metrics, both at the node level and network level (Kim *et al.*, 2011; Wichmann and Kaufmann, 2016).

Since the 1970s, the SNA approach has been widely adopted by different research areas ranging from sociology, anthropology to management studies and economics, (Borgatti and Foster, 2003; Sloane and O'Reilly, 2013). However, OM & SCM interest in SNA can only really be traced back to the 1990s (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). SNA directly addresses this soft side, offering insight into how personal relationships and knowledge diffusion processes translate into competitive advantage for organisations (Wichmann and Kaufmann, 2016). The potential of SNA approaches is reflected by three recent literature reviews, Borgatti and Li (2009), Galaskiewicz (2011) and Wichmann and Kaufmann (2016). Together these cover an overview of SNA theory and its adoptions particularly addressing supply chain management. Key insights drawn from these reviews, as well as their limitations, are provided in Table 1.

Table 1: Summary of recent literature reviews on SNA in OM and SCM

Reference	**Research Methodology**	**Relevance to OM/ SCM**	**Scope/Limitations**
Borgatti and Li (2009)	Narrative literature review	A starting point to confirm the possibility of embedding key SNA concepts in SCM contexts, such as centrality, structural holes and equivalence.	The focus is mainly limited to upstream/downstream linear value creation supply chains.
Galaskiewicz (2011)	Narrative literature review	Proposes that a social network perspective is very useful to study trust and opportunism issues in SCM. Highlights the importance of studying the dynamics rather than the structures of value creation.	Focus is mainly limited to supply side of SCM where value is created by delivering product/service to final customer. Does not include how to study the issues proposed.
Wichmann and Kaufmann (2016)	Systematic literature review	Examines the state of social network research in the SCM field. In particular, what phenomena to study and how to use SNA as an analytical tool in the research design process.	Focused on analytical method rather than the full extent of the SNA approach.

Although all three reviews are recent and address the importance of SNA and its potential role in SCM research, their focus is primarily on an archetypal supply chain, where the operations are defined as a set of sequential, vertically organised transactions that represent successive stages of value creation (Christopher, 1998). However, Borgatti and Li (2009) note

that, whilst the supply chain concept (with some adaptive planning and scheduling) is widely adopted, very few studies address operations with other types of co-ordination i.e. forms of interdependency and their associated value creation modes. For example, Thompson (1967) proposed a widely adopted typology of long-linked, mediating and intensive technology (Mello *et al*. 2015, Márcio 2016) that introduces the notion of different organisation forms creating value in different ways. According to Thompson's (1967) typology, supply chain value creation would be about standardisation and above all sequential dependence between supply chain actors; A adds value Aa and passes to B, B adds value Bb, so the total cumulative value is now Aa, Bb and is now passed to C, etc. However value can be created by other coordination frameworks that do not necessarily follow sequential dependence. In the field of strategic management Stabell and Fjeldstad (1998) build on Thompson's typology and focus on interdependencies to understand how different value configurations achieve competitive advantage (which they contrast to Porter (1985)'s notion of sequential value adding).

The three value creating configurations they identified were value chain (very like a supply chain), value shop (very like a service shop where the value is created by resolving a unique customer's problem) and value network (a very prescient forecast of the rise of network style businesses linking clients who wish to be interdependent). Based in the original paper on telephone companies, banks and insurance firms, it applies today to businesses like Facebook, E-bay, and LinkedIn. Beyond that these value configurations hold across a broad range of industries and firms, and in spite of these terms overlapping somewhat with other terms used in OM, this framework is adopted here. The reason being that it introduces differentiated forms of value creation in or by networks, each being inherently and analytically different, yet the simplicity and parsimony of the framework enable the focus to remain on investigating SNA. Note here that the use of Stabell and Fjeldstad's framework (ibid.) reinforces that our emphasis is on how SNA can help analyse OM and SCM however it is co-ordinated. Note also that in this study, social networks and supply networks can be two completely different concepts, discussions on potential 'fitting' challenges/appropriate translations can be found in Borgatti and Li, (2009).

Key linkages of the two concepts of value configuration and interdependence are presented in Table 2. Pooled interdependence tasks are vital to the efficiency of any kind of operation (Dubois *et al.,* 2004). An example of a typical inter-organisational pooled interdependence is a retail supply chain. The focal retail company manages separate suppliers

who do not necessarily need to coordinate with each other, however in combination they contribute discretely to the overall performance of the focal retailer (Crook and Combs, 2007). Thus being common to all value configurations pooled interdependence tasks are not discussed further here. Reciprocal interdependence involves simultaneous, ongoing relationships between actors in which one actor's input is dependent on another actor's output and vice versa. (An example could be where a script is passed back and forward between writers, each iterative stage improving the other's work; using the notation above such value creation could be Aaa,BbAaaaBbbbAB, etc., emphasising the iterative nature of value creation in this mode).

Table 2: Value configurations and its primary activity interdependence

Code	Chain	Shop	Network
Value creation logic	• Transformation of inputs into products	• (Re)solving customer problems	• Linking customers
Main interactivity relationship logic	• Sequential	• Cyclical, spiralling	• Simultaneous, parallel
Primary activity interdependence	• Pooled • Sequential	• Pooled • Sequential • Reciprocal	• Pooled • Reciprocal

-Adapted from (Stabell and Fjeldstad, 1998)

Wichmann and Kaufmann (2016)'s review focused on the adoption of SNA tools in SCM. Yet, extant literature suggests that as a theoretical discipline SNA encompasses more than just a set of analytical tools (Borgatti *et al.*, 2009). SNA analytical tools such as centrality measures have been able to analyse structures and relationships formally in mathematical terms; encouraging quantitative empirical research. However, a consequent downside has been that some scholars less familiar with the underlying social network theories, have misconceived the field as a quantitative methodology, (Borgatti *et al*., 2018). In fact, many studies have applied social network concepts without using the analytical tools (Dempwolf and Lyles, 2012). For example, Peng *et al.,* (2010) studied the triadic structure of supply networks and its implications for cooperative performance. They draw (*ibid.*) from social network theory to formulate six types of triadic structures, and adopted structural hole theory to propose why certain types of network structure are perceived to have higher cooperative performance. Although the size and range of the structures were not quantified, the unique triadic archetypes and their implications for performance brings new insights/lenses to OM research. The critical assumptions of SNA

on material and nonmaterial transfers between network structures have facilitated major research streams, notably social capital (Choi and Kim, 2008). Several approaches have been made to define social capital, either from a macro-level's perspective on structure led by Coleman (1990), Bourdieu, (1986) and Uzzi (1996), or the micro-level's perspective on relations led by Putman (2000) and Fukuyama (2000). Although approaches to the conceptualisation of social capital differ, they all follow the conventional concepts of SNA (Hatala, 2006), that is: theorising contexts as structure, and relationships as linkages shaped by, and in turn affected by, their embedded structure. Therefore, SNA in this study refers to both concepts derived from the SNA field (e.g. structural hole theory) and its analytical tools (e.g. centrality measures) building on the limitations identified in Table 1.

Thus, given our new approach, this study aims to answer the following two questions:

- *What is the current contribution of SNA to OM and SCM research?*
- *How should SNA contribute to OM and SCM research in the future?*

This study is structured as follows. Section 2 describes the SLR methodology adopted for this study, including details of the data collection, screening and analysis processes. Sections 3 and 4 respectively present the results of descriptive and thematic data analysis. Section 5 is a discussion addressing the research questions and building on these answers to create a three-part agenda for future OM and SCM SNA research. A short conclusion section summarises key findings and limitations.

2. Research methodology

To answer the research questions, this study examines the usage of SNA in OM and SCM, following a systematic literature review (SLR) approach. 'Usage' here means that a study either adopted concepts derived from SNA (such as treating established linkages/relationships as ties) as part of its theoretical framework to characterise position and structure; or that a study used SNA as a methodological tool, using measures such as centrality, density, etc. to measure/visualise certain structure/relationship/interdependence features. Unlike narrative literature reviews, an SLR is a transparent and evidence-based approach conducted by adopting a rigorous, replicable and scientific process (Tranfield *et al.,* 2003). The SLR follows three main steps: (1) Identification of data sources (2) Data extraction and synthesis (3) Data analysis and dissemination.

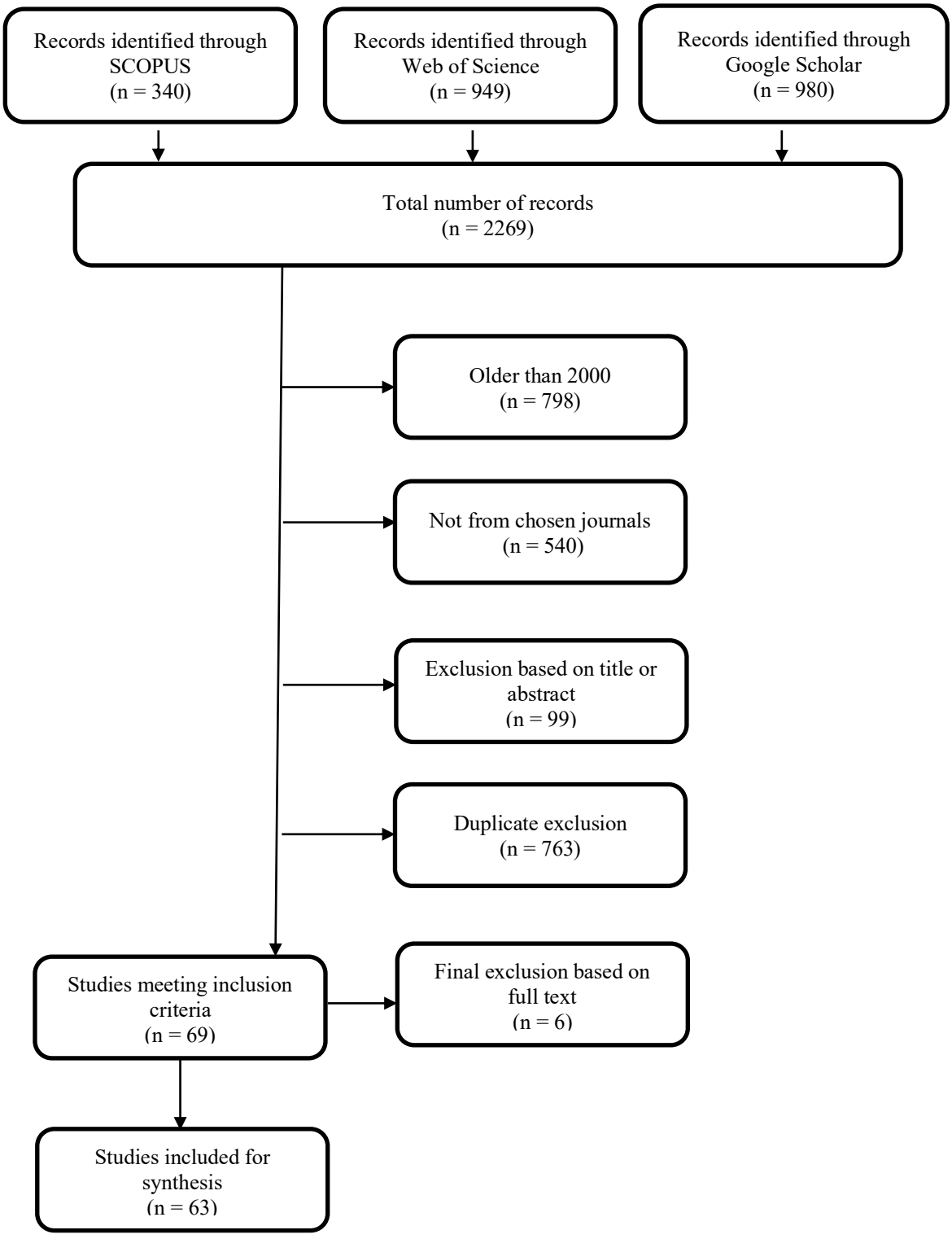

Figure 1. PRISMA approach for data screening

2.1. Identification of data sources

The first step for any SLR is the identification of keywords and databases (Arksey and O'Malley, 2005). Next, sources are narrowed down through the use of inclusion and exclusion criteria. Two primary (and associated) keywords '**Supply chain management'** *('supply chain', 'operation', 'SCM', 'ecosystem', 'supply network'*) and '**Social network analysis'** *('social network', 'degree centrality', 'network centralisation', 'network complexity', 'network density'*) were combined through a *Boolean logic* to search the databases.

Three databases namely *SCOPUS, Web of Science* and *Google Scholar* were searched. These databases are commonly employed for conducting SLRs (Fahimnia *et al.,* 2015). After consulting expert academics and previous literature reviews in OM discipline (e.g. Giunipero *et al.,* 2008; Kamel and Irani, 2014), a combination of peer-reviewed journals from the ABS (Association of Business Schools) journal ranking were chosen (See Table 3 for the journals selected).

2.2. Data extraction and synthesis

The data extraction and synthesis stage involves screening sources by carefully considering inclusion and exclusion criteria. Pre-defined inclusion and exclusion criteria are believed to generate high-quality knowledge discovery (Smithey, 2012). So called '*grey sources'* were excluded to support the focus on quality publications (Seuring and Müller, 2008); literature review papers on SNA were excluded. A PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analysis*) flow diagram (Figure 1) was created as a systematic method to visualise the study selection process (Moher *et al.,* 2009). Consequently, a total of 69 papers were selected for full reading. These 69 journal papers were read in full, but 6 were dismissed as not meeting the inclusion criteria leaving a final sample of 63.

2.3. Data analysis and dissemination

Beyond breaking the sample into smaller, coherent parts to drive analysis, this stage also examines the extent to which individual papers relate to each other (Denyer and Tranfield, 2009). At this stage, the full article texts were reviewed and coded according to three major analytical levels defined in Figure 2: research questions, data analysis and key coding categories.

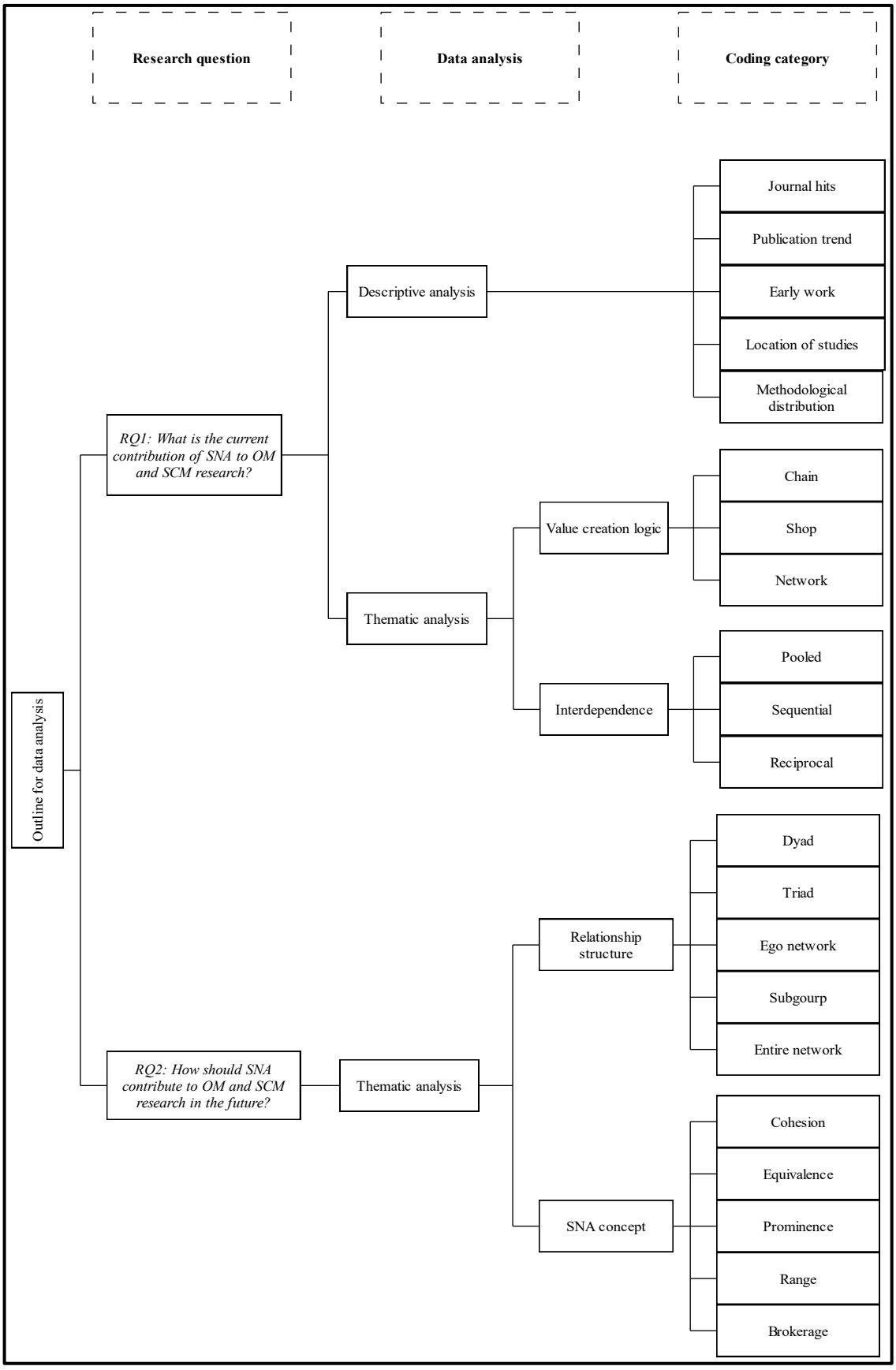

Figure 2: Data analysis process

RQ1 is addressed in two parts, based on the final sample of 63 papers. Firstly, descriptive analysis through the use of five relatively standard descriptive categories: journal search hits, publication trend, early work, location of studies and methodological distribution were developed. In parallel the two general thematic categories introduced above: value creation logic (Stabell and Fjeldstad, 1998) and type of interdependence (Thompson, 1967) are applied to each paper in the sample. Combined, the descriptive and thematic analysis (specifically value creation logic and type of interdependence) will identify the current contribution of SNA in OM & SCM research.

For RQ2, two additional thematic categories: relationship structure (Wasserman and Faust, 1994; Wichmann and Kaufmann, 2016) and key SNA concepts (Haythornthwaite, 1996) will examine how and why SNA concepts could help to address the areas that as a by-product of RQ1 were identified as having received less research attention to-date.

3. Descriptive analysis and results

3.1. Journal hits

Table 3 presents the journals used, the number of hits per journal included for synthesis and their ABS ranking.

Table 3: Selection of journals and associated hit numbers

Subject filed	Journal	Hits	ABS ranking
Operations research and management science	Journal of Supply Chain Management (JSCM)	16	3
	Journal of Operations Management (JOM)	7	4
	International Journal of Production Research (IJPR)	7	3
	Supply Chain Management: An International Journal (SCMIJ)	7	3
	International Journal of Operations and Production Management (IJOPM)	5	4
	Journal of Purchasing and Supply Management (JPSM)	5	2
	International Journal of Production Economics (IJPE)	4	3
	Production Planning and Control (PPC)	4	3
	Journal of Business Logistics (JBL)	4	2

	International Journal of Logistics Management (IJLM)	3	2
	International Journal of Physical Distribution and Logistics Management (IJPDLM)	1	2
	Management Science	0	4
	Operations Research	0	4
	Manufacturing and Service Operations Management	0	3
	Decision Sciences	0	3
Marketing	Industrial Marketing Management (IMM)	0	3
Service sector	Journal of Service Research	0	4
	Service Industries Journal	0	2
Total hits		**63**	

3.2. Publication trend

Figure 3 shows the publication trend option for SNA work in the sample over the past nineteen years. Note that over half of the selected papers are published in the last six years; and also the relative newness of OM SNA work – really only appearing from 2007.

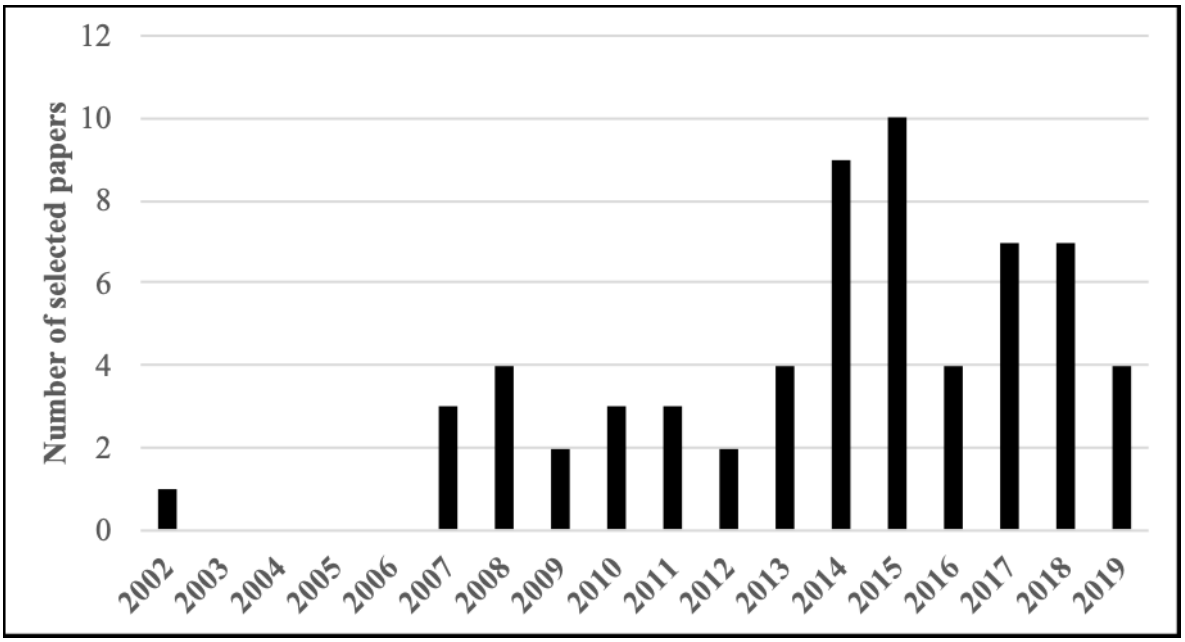

Figure 3: Number of publications per year

3.3. Early work

Early work by Burkink (2002) explored the impact of alternative channel structures on inter-firm knowledge transfer by conceptualising linkages between individuals as strength of ties among different channel structures. Later, Camarinha-Matos and Abreu (2007) introduced a number of measurable performance indicators for collaborative networks by adapting the concept of centrality and prestige from social network theory. It is interesting to note that, social network theory was not empirically tested in OM until the study conducted by Kim *et al. (*2011). They applied SNA as their methodology to study social networks in the automotive industry. This study was a catalyst for further use of SNA in SCM. Adoption of SNA has gradually increased, reaching its peak year in 2015, when several studies were published on a buyer-supplier relationship from dyadic, triadic and entire network perspectives due to a special issue on power in supply chain management.

3.4. Location of studies

The location of the selected studies was analysed based on the location of where data was collected. Most of the studies were conducted in North America, Europe and East Asia.

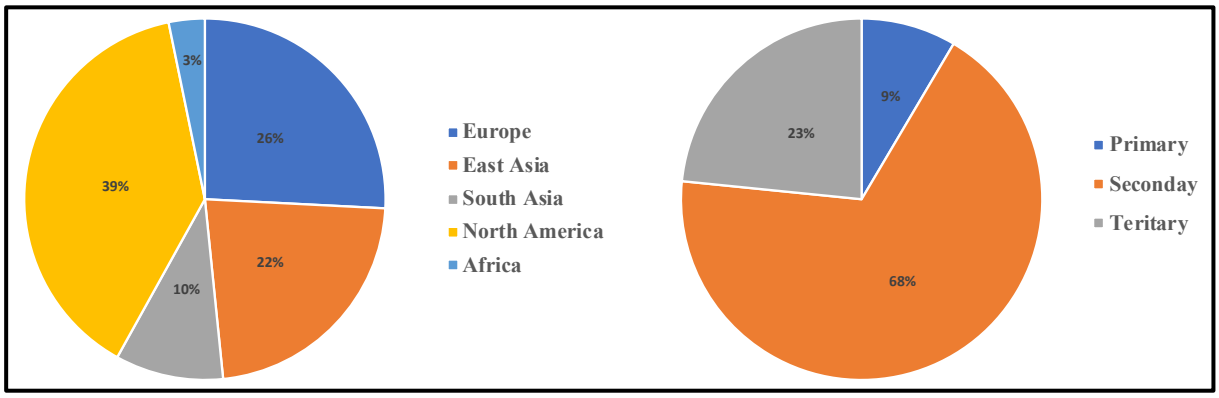

Figure 4: Region and sector research focus

In terms of sector the sample of OM and SCM SNA papers is dominated by the primary (raw and agricultural materials) and secondary sectors (produces consumption and investment by combining raw materials and labour, such as manufacturing and construction industry), comprising over 90% of the sample. Key growth areas of modern economies, service sectors such as banking and insurance, administration, government, ICT and other knowledge-based sectors are under-represented.

3.5. Methodological distribution

In general, research methods can be identified as qualitative, quantitative and mixed methods. Figure 5 summarises the distribution of research methods in the sampled papers. In terms of summarising methods, many papers use more than one research method, as they cover both qualitative and quantitative methods. This study identifies such papers as mixed methods.

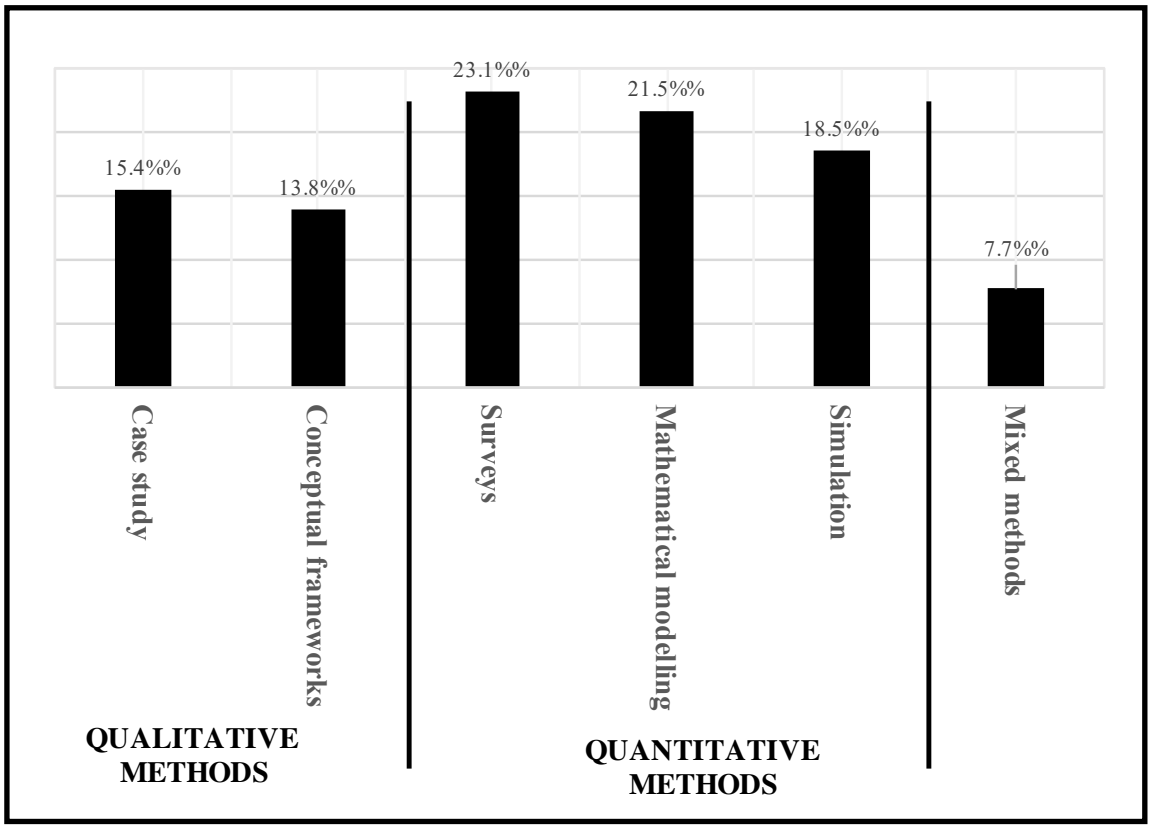

Figure 5: Distribution of methodological approaches

3.6. Summary of descriptive studies

The descriptive analysis shows that the number of research studies adopting an SNA approach to OM studies has been increasing gradually since 2007 (Figure 3). Table 3 shows that whilst two main-stream OM journals (JOM and IJOPM) together published a respectable 12 SNA studies, two supply chain journals (JSCM and SCMIJ) combine constitute 21 of the 63 studies used in this study. Add in the other supply chain and logistics journals and to-date SNA has clearly been adopted in a supply/logistics context. Also, from the industry sector overview (section 3.4), it is clear that current OM work is dominated by the primary (classically agriculture and mining) and secondary sectors (classically manufacturing) with services, IT, etc. under investigated. Finally from Figure 5, quantitative approaches to SNA dominate the

methodological approaches used in the sample papers. This is supported by the propensity of current literature to view SNA as a method or toolkit rather than a theoretical perspective.

4. Thematic analysis and results

Following the descriptive analysis above, this section will present the thematic findings derived from the analysis in Figure 6. Figure 6a addresses the first research question- *What is the current contribution of SNA to OM and SCM research?* Building on the answers to RQ1, Figure 6b addresses the second research question - *How should SNA contribute to OM and SCM research in the future?* Note that in Figure 6, percentages indicate the number of that particular single attribute out of the total number of reviewed papers so that where papers have more than one attribute (e.g. investigate both dyad and triad structures) then totals do not always add up to 100%.

In Figure 6, the percentages in the boxes indicate the number of that particular single attribute out of the total number of papers reviewed. The percentages on the arrows indicate the number of that particular attribute out of the total number of the attribute above. For example, papers that take dyad structure as their unit of analysis to examine reciprocal interdependence account for 21% of the total number of papers analysing reciprocal interdependences. Note that for the value creation logic row, some papers do not clearly mention their value logic; for the other three rows, some papers have more than one attribute e.g. investigate both dyad and triad structures. For these two reasons, row totals do not always add up to 100%.

4.1. Value creation logic and type of interdependence: RQ1

In the sample of 63 papers, the value creation logic of chains (value creation through sequential interdependence) dominates in Figure 6a, being employed in three times the number of papers as alternative value creation approaches combined; 71% of the total papers were identified as chain and sequential. Papers that used shop or network value creation (Stabell and Fjeldstad, 1998) with therefore either sequential and reciprocal or just reciprocal interdependency were undisputedly in the minority.

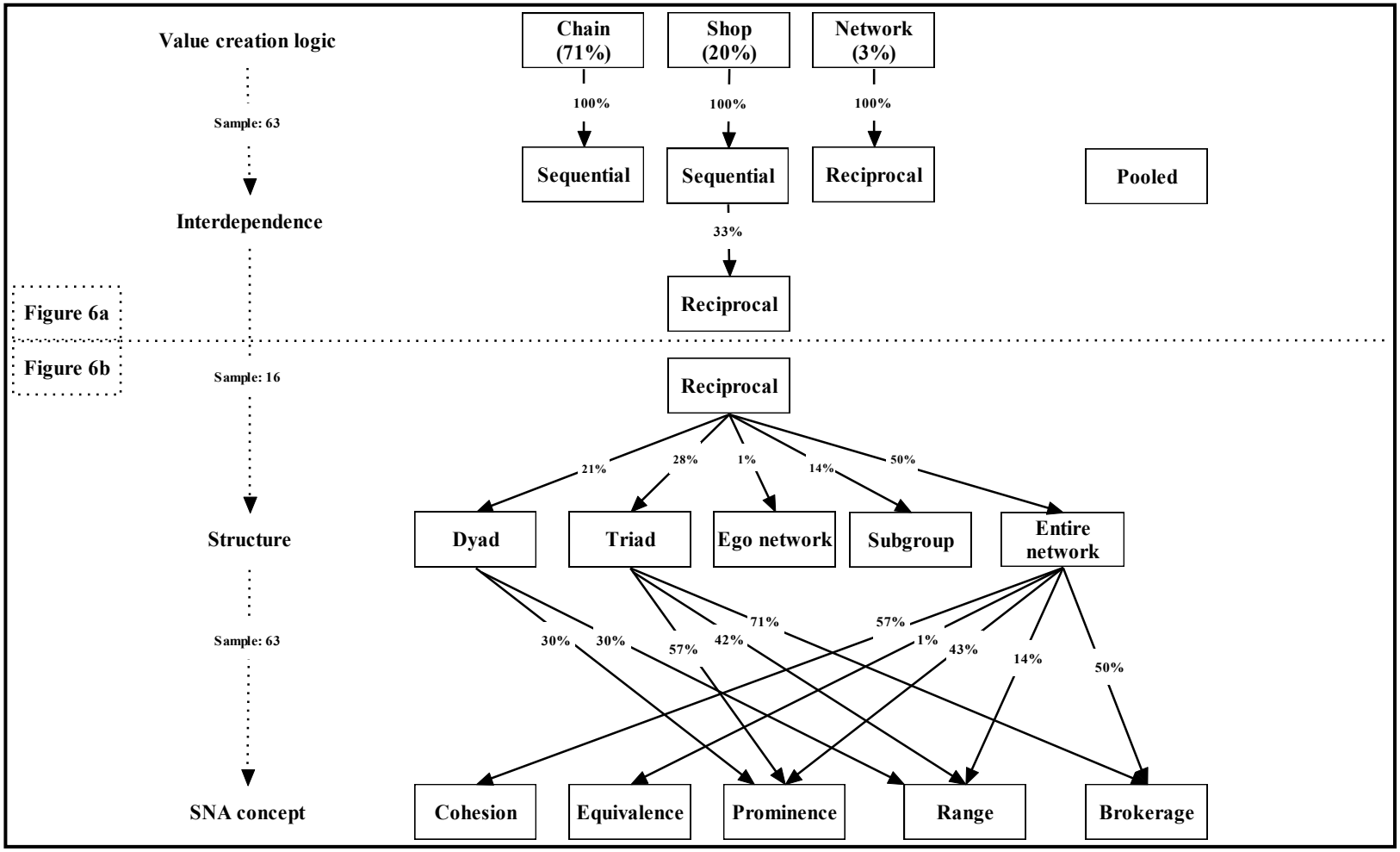

Figure 6a and 6b: Results of thematic analysis

4.1.1. Reciprocal interdependence and relationship structure

Next in Figure 6b the connections between reciprocal interdependence and relationship structure are investigated using the 16 reciprocal papers in our sample. According to Wasserman and Faust (1994), the investigation of social networks can involve dyads (two actors and their relationship), triads (three actors and their relationships), ego network (a focal actor and its surrounding actors, and relationships among them) as well as larger structures such as subgroups (subset of a larger network) and entire networks (all of the actors and their relationships in a unique network). Figure 6b shows that dyad (21%), triad (28%) and entire network (50%) structures dominate studies into reciprocal value creation activities. While ego network and subgroup, are popular SNA structures or units of analysis in OM and SCM, in our sample of 16 papers using reciprocal interdependence, examples of ego network and subgroup were predominantly used to study sequential value creation adding and so are not taken further in the analysis here.

4.1.2. Relationship structure and the adoption of SNA concepts

4.2.1 above used the 16 papers identified as using reciprocal independence to map connections with relationship structure. This section uses all of the 63 papers across sequential and reciprocal interdependence, to map the connections between relationships structure and the SNA concepts adopted in each study.

Five concepts from social network theory were identified: cohesion (57% from entire network), equivalence (1% from entire network), prominence (30% from dyad, 57% from triad and 43% from entire network), range (30% from dyad, 42% from triad and 14% from entire network) and brokerage (71% from triad and 50% from entire network). Detailed explanations of what these five general SNA concepts stand for, what methodological or perspectives they include, and examples of how they have been applied in the sample papers are presented in Table 4. Gaps in column six, seven and eight (headings are dyads, triads and networks) mean that no example was found in our sample papers. This indicates that no connection was found between relationship structure and SNA concept (e.g. no dyadic study adopted cohesion as a SNA concept). Also note that the SNA concept of equivalence (see Table 4) in OM and SCM is only used in one paper (Zhang *et al*. 2013) in the full sample of 63.

Table 4: SNA concepts employed in reviewed papers

	Description and potential contribution to OM & SCM research	**Perspective /method**	**Approach**	**Description**	**Selected examples in different unit of analysis**		
					Dyad	**Triad**	**Entire network**
Cohesion	Measurements and concepts that describe the cohesiveness of the whole network, indicating the likelihood of strong common relationships between actors in the same network (Haythornthwaite, 1996).	method	Network density	Reveals the level of connectedness between network members. It measures the number of total existing ties in a network in relation to the number of all possible ties (Scott, 2000).			(Cheng *et al.,* 2017) (Adenso-Diaz *et al*., 2012) (Camarinha-Matos and Abreu, 2007)
			Small world typology	An approach that simulates real world network as a combination of two polarised structures: highly clustered networks and random networks (Watts and Strogatz, 1998).			(Menezes *et al*., 2018) (Negahban *et al.,* 2014)
		Perspective	Embeddedness	A central construct in network theory that refers to the state of dependence of members in a certain network structure (Choi and Kim, 2008). It shows how the common ties between network actors are interconnected (Borgatti and Foster, 2003).			(Nair *et al.,* 2018) (Tukamuhabwa *et al*., 2017) (Kim, 2017) (Tate *et al.,* 2013)
Equivalence	Identifies actors with similar roles (Haythornthwaite, 1996). Structurally equivalent actors	Method	Structural equivalence	Two forms are structurally equivalent to the extent, they have same customers and			(Zhang *et al.,* 2013)

	are those who have the same types of ties to and from all other actors in the network (Wasserman and Faust, 1994).			supplier (Borgatti and Li, 2009), and this similarity may provide a performance benchmark or stimulus for innovation adoption.			
Prominence	Indicate which actor or cluster of actors have power or influence within a network (Haythornthwaite, 1996), and who is in demand (Nohria, 1992).	Method	Degree centrality	Measures the number of relationships one actor maintains in a given network. A high degree centrality indicates the actor has a central position in the network and will be more visible (Marsden, 2002).		(Swiercze, 2018)	(Ting *et al.,* 2014) (Sloan and O'Reilly, 2013) (Yu *et al.,* 2008) (Carter *et al*., 2007) (Wichmann *et al.,* 2015)
			Closeness centrality	Focuses on how close an actor is to all the other actors beyond those it is directly linked to in the network. Actors with high closeness centrality can quickly have access interaction with all the others (Wasserman and Faust, 1994). Such nodes become less reliant on the others (Kim *et al*., 2011).			(Ting *et al.,* 2014) (Kim *et al.,* 2011) (Carter *et al*., 2007)
			Eigenvector centrality	Capture the number and importance of adjacent nodes around an actor. Actors with high eigenvector centrality is likely to have higher influence	(Carnovale *et al*., 2017)		(Stolze *et al*., 2018)

				towards decision-making (Wasserman and Faust, 1994).			
		Perspective	Social capital	The collection of resources that a firm received as a result of possessing a network of inter-firm relationships, and is context –specific therefore sensitive to changes (Dyer and Singh, 1998). This perspective highlights the value of relationships instead of the actors themselves (Borgatti and Foster, 2003).	(Whipple *et al.,* 2015) (Lawson *et al.,* 2008)	(Hartmann and Herb, 2014) (Li and Choi, 2009)	
Range	Refers to the size of the network. The bigger the size, the more resources and information an actor has access to, and the more access to places where the resources can be used (Burt, 1992).	Method	Network size	The number of suppliers has a moderating impact on the type of strategies to foster supplier's performance (Terpend and Ashenbaum, 2012).		(Swiercze, 2018)	(Negahban *et al.,* 2014) (Kim et al., 2011)
		Perspective	Graph theory	Identification of available arrays of contacts help to visualise the micro-interactions that formulate macro-organisational structure (Carter *et al*., 2007).	(Ekanayake *et al.,* 2017) (Kim and Choi, 2015)	(Ekanayak *et al.,* 2017) (Peng et al., 2010)	
Brokerage	A process of linking otherwise isolated individuals (or group) (Zaheer *et al*., 2010). Strengthening and maintaining opportunities is valuable for sourcing firms to put them a strategic position by having	Method	Betweenness centrality	The share of times an actor is needed to be the shortest pathways between other pairs of actors in a network (Scott, 2000). Strong betweenness centrality indicates control of information and resources.		(Swiercze, 2018)	(Wichmann *et al.,* 2015) (Ting *et al.,* 2014) (Sloan and O'Reilly, 2013)

	access to a diverse set of partners and resources (Burt, 2004).				(Kim *et al.,* 2011) (Yu *et al.,* 2008) (Carter *et al.,* 2007)
		Perspective	Structural hole	A situation where two actors are disconnected in a network. Actors that bridge two otherwise disconnected parties could benefit from the mediating role as a conduit for additional resources and information (Burt, 2004; Obstfeld, 2005).	(Wagner *et al.,* 2018) (Peng *et al*., 2010) (Choi and Wu, 2009) (Li and Choi, 2009)	(Kim, 2017)

5. Discussion

This review has proposed that the SNA approach provides numerous tools to map and evaluate social attachments and non-linear interdependences such as knowledge transfer (Rowley *et al.*, 2000), firm innovation (Tate *et al.,* 2013), power and alliances (Kim, 2017) and risk identification (Li and Choi, 2009). Unlike conventional supply chain analysis, SNA does not particularly focus on elements related to vertical transactions (Lazzarini *et al.,* 2001). For example, Choi and Kim (2008) noted that although it lacks direct transactions, the extended supplier's innovative networks may impact on the buying company's performance. Schoenherr *et al.,* (2015) also suggested that the unstructured, informal interactions among individuals and firms are crucial for the assurance of food safety in supply chains. Studying these unexamined relationships (types of interdependencies) offers a new opportunity for supply chain scholars (Autry *et al*., 2008; Davis-Sramek *et al*., 2010).

As the final part of answering RQ2, the next section suggests a research agenda for future OM and SCM scholars interested in the SNA approach.

5.1. RQ1: What is the current contribution of SNA to OM and SCM research?

The disproportionate use of chain and sequential interdependence allows us to conclude that to-date OM and SCM have used SNA in manufacturing and high volume, fast moving supply chain environments, where the value adding process is both linear and largely visible and/or relatively predictable. Referring back to Thompson's (1967) view of interdependency we can also state SNA has been most commonly applied in industries governed by standardisation and the transformation of inputs into outputs at a number of connected stages. This answer is supported by the descriptive analysis which shows (Figure 4) that the sectors studied are largely dominated by the secondary sector, e.g. manufacturing and construction. Such reliance on archetypical Porter (1985) value chains works best when there is the certainty and planning time frames associated with predictable environments.

Although there is growing interest in the SNA approach in OM & SCM research (Publications trend, section 3.2), extant literature is dominated by investigating sequential relationships in a chain value configuration. This is logical, since operations management is heavily associated with manufacturing industry (Burgess *et al.,* 2006). However, the supply networks of manufacturing companies have become increasingly 'disaggregated', with activities spread across different firms and geographically distributed locations (Srai and

Tiwari, 2016). These phenomena of disaggregation and the aligned complexity inherent in contemporary manufacturing industries will only increase the number of non-chain value configurations in line with the growth of services and social and industrial networks. Whilst acknowledging the role that SNA can play in sequential value chains, e.g., the ability to map the inter-organisational relationship structures (Carnovale *et al.,* 2017) , the movement of resources and the direction of influences (Granovetter, 1977; Nohria, 1992; Wasserman and Faust, 1994; Burt, 2005), OM and SCM researchers should not exclude the application of SNA to other roles.

5.2. RQ2: How should SNA contribute to OM and SCM research in the future?

The answer to RQ2 is novel and bold, presenting a new research agenda that includes recognising the importance of reciprocal interdependence between actors/entities. This latter contribution to answering RQ2 is discussed here, while the new agenda response to RQ2 is presented in sections 5.1-5.3. Stabell and Fjeldstad (1998: 422) identified reciprocal interdependence as shop value creation logic; interactive actions from ongoing mutual adjustment. Service shops in their framework solve unique customer problems through non-linear, but interactive activities, that diagnose back and forth, before deciding on the most appropriate solution. This answer is supported by the descriptive analysis (Figure 4a) which shows support for the need for more studies involving the service dominated tertiary and (and emerging quaternary) sectors (Figure 4b). According to Baines *et al.* (2009), success in service operations tends to be more associated with intangible and subjectively assessed attributes such as reliability and speed of response rate (Voss, 2003). The testing, refinement and improvement of new services therefore tends to be done in the field with the customer, since solving a unique problem is where the service value comes from (Thompson, 1967; Sousa and de Silveira, 2019). This requires the development of customer trust and an understanding of customer habits and behaviour (Smith *et al.,* 2014). One of the most significant goals of the SNA approach, however, is the study of the similarity of choice (Borgatti *et al.,* 2018). This includes behaviours, attitudes, beliefs and internal structural characteristics, e.g. explaining which pairs of nodes make similar choices (Borgatti and Halgin, 2011). For this reason, theoretically SNA is a natural partner for service style value configuration research as it can help understand and explain subjective ratings which help service companies in making decisions on ways to adapt their strategies in a given relationship constellation (Wagner *et al.,* 2018).

5.2.1 To improve the coverage of social and relational people issues in OM.

It was once the consensus that individual firms do not compete with each other, but that their supply chain competes with other supply chains. As production and distribution systems increasingly converge on variations of dominant designs, it is more accurate to state that it is a supply chain's people who compete with the people of other supply chains. It is the metaphorical glue of social and relational ties that creates this intangible resource. Yet OM and SCM theory has been dominated by viewing global supply chains as primarily chains of economic transactions (Reinecke *et al.,* 2018), where the logic of transaction costs and the structural position of economic actors shaped how value chains are governed (Gereffi *et al.,* 2005). The effect of the 'people dimension' of the supply chain has been under-researched (Tokar, 2010; Wieland *et al.,* 2016; Schorsch *et al.,* 2017). Both OM and SCM have long been criticised for lacking a people perspective, an interest in how people function (Storey *et al.*, 2006). As an SLR on SCM found "…*the low representation of articles focusing on psycho-sociological research was unexpected. Since, SCM involves engagement of people from different backgrounds, occupational groupings, geographical locations and cultures, one would expect stronger coverage of social issues than appears to be the case*" (Burgess *et al.,* 2006). Beyond the individual, multinational companies and those that trade internationally must increasingly respond to and comply with, host and home country concerns and customs (Lavastre *et al.,* 2012) and be seen to be both inclusive and diverse. While commercial inter-firm relationships may be based on an actor's economic power (Gereffi, 1994), SNA offers important insights into coordination across boundaries, economic transactions are inherently 'embedded in concrete, ongoing systems of social relations' (Granovetter, 1985; Uzzi, 1997).

5.2.2 To increase OM coverage of 'dark side' risk.

According to many in the television media, the US programme "The Wire" is the greatest television programme ever made. Whilst addressing many themes a core one was the police use of mobile phone tapping to penetrate criminal drug gangs' activities; the chance use of the SNA concept of prominence (Sloan and O'Reilly, 2013; Yu *et al*., 2008; Carter *et al*., 2007) analysis. The Wire can be mentioned as it is public material, more SNA informed and SNA sophisticated methods are currently being deployed in police, military and state initiatives to map and then disrupt the activities of organised crime networks operating in human, animal, gun and drug trafficking, money laundering, sex crimes and terrorism. So called 'dark networks,

in that their activities are both covert and illegal' (Raab and Milward, 2003). What is highly relevant to OM and SCM is that often these dark networks reflect emergent, and sometimes temporary and non-hierarchical organisational forms; 'Traditional physical crime is migrating to cyber based crime-networks' (Brocklesby, 2012). Social network analysis can be used to try and understand these dark enterprises/threats as dynamic entities. For example structural hole and brokerage theory (Burt, 1992) has been applied to entire network structures in order to identify those firms who have better access to information and exchanges (Sloan and O'Reilly, 2013), and faster response to supply disruptions (Kim *et al*., 2011). SNA can help address the issues caused for regulators by the very dynamism and fluidity that can make these dark networks resilient (Bakker *et al*., 2012); luckily such work is being undertaken around the world, but it is of necessity covert and does not appear in OM journals – but see Ting and Tsang (2014) for one example in our SLR that addresses counterfeiting. In using SNA methods and social network perspectives to reduce the impact of organised crime, drug tracking and terrorism we offer some powerful responses to the legitimate question often asked of SNA, *why do we need to know who talks to whom?* Even when issues of fluid and non-hierarchical organisational forms are not related to crime, there is still a perception that OM is not using SNA to address contemporary issues such as the gig economy and corporate and for/not for profit entrepreneurial incubators (e.g. classic SNA brokerage theory, Burt 2005; Zaheer et al., 2010 combined with SNA range concept Kim et al. 2011; Swiercze 2018) for which it is ideally suited.

5.2.3 The growing intangibility of OM and SCM.

The SNA concept of range enables visualising dispersed network resources (Carter et al., 2007). One driver for the increased use of SNA is that industrial organisations are increasingly virtual and networked (Industry 4.0., the IoT, digital manufacturing), where at least some of the advantages of proximity are lost. This increased reliance on technology for communication means that organisations have to work harder to understand communication, diffusion (Hearnshaw and Wilson, 2013) and innovation patterns (Carnovale, 2015). In-spite of initiatives like big data, technological mediation still needs some human intervention and interpretation to comprehend and therefore manage strategic information. SNA and social network perspectives on OM are needed in an increasingly "intangibly" connected world. Here the SNA concept of cohesion can be used to indicate the quality of collaboration and the

potential for repeated transactions in the future (Camarinha-Matos and Abreu, 2007; Nair *et al*., 2018), effective information exchange that drives the diffusion/implementation of certain business practice (Adenso-Diaz *et al*., 2012; Tate *et al*., 2013), as well as the probability of customer preference change due to social influence (Menezes *et al*., 2018). SNA's ability to measure the level of cohesiveness is suited to managing contemporary disaggregated and dispersed organisations linked by technology through measuring connectedness between network members indicating the likelihood of strong common relationships.

6 Conclusions

A rigorous, replicable structured literature review on SNA in OM & SCM was conducted. Based on the SLR, 63 reviewed papers were synthesised into 21 dimensions (coding categories in Figure 2) to explore two research questions broadly covering what is currently being studied and what should be being studied, using SNA in OM and SCM research.

There are two main limitations in this study. The first is that the framework adopted here from Stabell and Fjeldstad (1998) may have biased the sample papers to coordination issues. However, this framework did enable us to develop an in-depth understanding of how value was created in a variety of OM and SCM contexts and therefore how distinctly a SNA perspective could add to knowledge. Secondly, in terms of the SNA method, there are many problems that others have alluded to. Boundary specification is a defining issue of any empirical network research (Provan and Sebastian, 1998; Sloane and O'Reilly, 2013), raising particular difficulties for data collection when bounding networks (Butts, 2008; Sloane and O'Reilly, 2013). Snowballing (Moriarty, 1983), roster call (Giuliani, 2006; Morrison, 2008) and survey methods have been employed to mitigate this challenge. Also, when collecting social network data, it is problematic to guarantee respondents' anonymity; thus, potential participants tend to be reluctant to take part (Borgatti and Molina, 2003). Undoubtedly the issue of guaranteeing the confidentiality of SNA research participants is made more difficult by the reciprocal approaches recommended here. Powerful new software programmes offer some hope here, see Wichmann and Kaufmann (2016) and Galaskiewiz (2011) for an informed discussion.

In conclusion, this study addresses the current focus of SNA use in OM and SCM and identified that extant literature is skewed to sequential patterns of value creation i.e.

archetypical manufacturing and supply chain management. This is at the expense of researching more service and network value creation configurations and arguably out of synch with the faster growing sectors of modern economies. The study offers clear guidance in terms of how SNA methods and concepts have been, and could be used, in ways that speak to emerging business models. We suggest this study both encourages, and provides an agenda for, OM and SCM researchers to use SNA approach.

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