

KNOWNET 324408

**SOCIAL NETWORKING SYSTEMS AND
SOCIAL NETWORK ANALYSIS.
LITERATURE REVIEW.**

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Social networking systems and social network analysis: a literature review

Abstract

The aim of this paper is to review the literature on immersive social networking systems and social network analysis (SNA). There is a special interest in SNA applications within the insurance sector. In addition this literature review has a interest in research that use collaborative technologies to develop platforms and social network sites in order to automatically collect data, infer social networks and even map knowledge or learn relational policies in large scale organizations. This paper details the findings of the current state of the art on knowledge networking models and social networking technologies.

Key words: Social networking systems, social network analysis, collaborative technologies, knowledge platform, knowledge network.

1. Introduction

A network is a set of actors connected by a set of ties (Borgatti and Foster, 2003). The elements of the network are often referred to as vertices, nodes or actors and the size of a network is the total number of nodes and contacts that compound the network (Martinez-Lopez et al., 2009). The actors can be people, teams, organizations, concepts, etc. Ties connect pairs of actors and can be directed (i.e., potentially one-directional, as in giving advice to someone) or undirected (as in being physically proximate) and can be dichotomous (present or absent, as in whether two people are friends or not) or valued (measured on a scale, as in strength of friendship) (Borgatti and Foster, 2003).

Social network analysis (SNA) provides researchers a descriptive and statistical method to understand how supply chain components are positioned, connected and embedded within the supply chain system by using both node- and network-level measures (Wasserman and Faust, 1994). SNA has emerged as a key technique in modern sociology, anthropology, geography, physical sciences, social psychology, information science and organisational studies. Social network theory views social relationships in

terms of nodes and ties. Nodes are the individual actors within the networks, and ties are the relationships between the actors. The emphasis lies on the relationships and the ties between actors within the network and the structure of the network and the quality of the relations are the main determinants of its usefulness to its participating individuals (Caniels and Romijn, 2008). SNA aims to describe the interactions between individuals within a group (Anderson and Jay, 1985; Granovetter, 1985; Wellman, 1988) and to understand the collective behaviour of a group (Laumann and Pappi, 1976). Thus, the links or connections among the elements are usually referred to as edges or contacts (Martinez-Lopez et al., 2009). When we focus our attention on a single focal actor, we call that actor “ego” and call the set of nodes that ego has ties with “alters” (Borgatti and Foster, 2003). The lack of ties among an actor’s alters is called structural holes (Burt, 2009). ‘Board interlocks’ are ties among organizations through a member of one organization sitting on the board of another (Borgatti and Foster, 2003). For a detailed description of the assumptions, goals and explanatory mechanisms of SNA, we refer readers to Borgatti and Foster (2003) and Borgatti et al. (2009).

In this paper, we present a literature review on social network systems and SNA. The main contributions of this paper are: (1) to provide a review of social network systems and SNA from last ten years; (2) to organize the main insights in order to support and facilitate exchange of the main SNA objectives, applications, methods and software tools; and (3) to analyze the main contributions and limitations of reviewed papers in order to identify gaps for SNA future researches. The remainder of the paper is structured as follows. Section 2 describes the review methodology. Section 3 proposes a taxonomy for the reviewed papers based on their objectives and applications, modelling approaches, used tools, advantages and disadvantages. Section 4 discusses the main findings and future research opportunities. Section 5 provides a conclusion.

2. Review methodology

The literature review was done using the scientific technical bibliographic ISI Web of Knowledge database (WoK) with a time window of 10 years from now, although some papers were obtained from selected references after being reviewed. The main focus of the selected references were SNA and its applications. There was special interest on SNA in the insurance sector because this study is generated in the framework of the EC funded Marie Curie IAPP EU project entitled KNOWNET— Engaging in

Knowledge Networking via an interactive 3D Social Supplier Network (FP7-PEOPLE-2012-IAPP). The KNOWNET project seeks to assess the value of social networking for knowledge exchange across Insurance supply chains. A key objective of the project being to develop and build a web based interactive environment - a Supplier Social Network or SSN, to support and facilitate exchange of good ideas, insights, knowledge, innovations etc across a diverse group of suppliers within a multi level supply chain within the Insurance sector (Grant, 2014). Also, the development of collaborative platforms or social network sites for automatically collecting data or knowledge mapping in large size organizations were considered as a research and selection criterion. Moreover, some references about open source software for SNA were also taken into account. Taking into consideration the number of software developed for this matter, it can be noted that lately there is an increasing aim trying to explain and understand behaviours, network structures, flow incomes and outcomes. Scope was considered international for references with a country, region or global focus and no time frame was defined in this literature review. References to service network enterprises at international environments were also considered as well as product networks. No SNA applications in national security or war/crime fighting have been considered to be out of the scope of the KNOWNET project. The articles were researched through the combination of several keywords and selected based on our previously indicated selection criteria. The number of selected papers by searching key words are shown in Table 1.

Table 1. Key words and selected references

Key words	References
SOCIAL NETWORK ANALYSIS SERVICE, NETWORK, INNOVATION, LEARNING, PLATFORM	1
SOCIAL NETWORK ANALYSIS, INSURANCE, NETWORK, INNOVATION, LEARNING	1
SOCIAL NETWORK ANALYSIS, OPEN SOURCE COLLABORATIVE SOFTWARE	2
SOCIAL NETWORK ANALYSIS ,TECHNIQUES	9
SOCIAL NETWORK ANALYSIS, SUPPLY CHAIN	2
SOCIAL NETWORK ANALYSIS, KNOWLEDGE NETWORK	9
Total	24

Table 2 presents the journals and number of articles selected to describe the sources used.

Table 2. Classification of sources by number of contributions

Source	Number of references	Total %
BMC Research Notes	1	1
Educational Technology & Society	1	1
Entrepreneurship and Regional Development	1	1
Futures	1	1
Higher Education	1	1
Industry and Innovation	1	1
Information Sciences	1	1
Journal of American Medical Informatics Association	1	1
Journal of Biomedical Informatics	1	1
Journal of Economic Geography	1	1
Journal of Knowledge Management	1	1
Journal of Management	1	1
Journal of Management Studies	1	1
Journal of Product Innovation Management	1	1
Journal of Supply Chain Management	1	1
Journal of the American Medical Informatics Association	1	1
Plos One	1	1
Regional Studies	1	1
Research Policy	1	1
Science	1	1
Social Science & Medicine	1	1
SPRU Electronic Working Paper Series	1	1
Systems Engineering	1	1
Transboundary and Emerging Diseases	1	1
Total	24	100%

3. Taxonomy

The proposed taxonomy classifies the reviewed works by identifying their contexts and objectives, research methodology, modelling approaches, used tools, advantages and disadvantages.

3.1 Context and objectives

In the first place, a review carried out by Borgatti and Foster (2003) needs to be highlighted since it establishes a set of dimensions along which network studies vary, including direction of causality,

levels of analysis, explanatory goals, and explanatory mechanisms. The authors use explanatory goals, and explanatory mechanisms dimensions to construct a 2-by-2 table cross-classifying studies of network consequences into four canonical types: structural social capital, social access to resources, contagion, and environmental shaping. Then, Borgatti et al. (2009) review the aspects studied by social scientists through SNA by organizing the main concepts of social network theory and comparing them with the network approach used in the physical sciences. The authors indicate that national security, public health and management consulting –mainly, knowledge management- were the main applied fields where SNA has been used in the 1990s. From our review, we also identify that the health sector and knowledge networks continue being the main fields for SNA applications without considering security applications.

SNA applications in knowledge networks

In the context of knowledge networks, Giuliani and Bell (2005) apply SNA to identify different cognitive roles played by cluster firms and the overall structure of the knowledge system of a wine cluster in Chile. Giuliani (2007) applies SNA to explore the structural properties of knowledge networks in three wine clusters in Italy and Chile. In Giuliani and Bell (2008), the authors repeat their earlier study in Giuliani and Bell (2005) but with data from other point of the time. Boschma and Ter Wal (2007) conduct a SNA to draw the configuration of the knowledge network of the footwear district of Barletta and assess which factors may have contributed to the innovative performance of footwear firms in this district. Sammarra and Biggiero (2008) identify that these previous works and similar ones have been more focused on structural properties of networks and less on the specific knowledge content of relationships occurring between network nodes. By using SNA methods, the authors illustrate an empirical study of technological, market and managerial knowledge exchange in innovation collaborations. Research undertaken by Morrison (2008) investigates whether leader firms located in a successful Italian furniture district feed the district with knowledge absorbed from external sources, thereby behaving as ‘gatekeepers of knowledge’. Morrison and Rabelloti (2009) analyse the nature and extent of knowledge and information networks in an Italian wine cluster and the relation between firms’ characteristics and the knowledge network structure. Ramírez-Pasillas (2010) analyses a Swedish furniture industry cluster and make a conceptual contribution of the role of international trade fairs for amplifying proximities in clusters. Capó et al. (2013) contribute to the debate on the

role and value universities play as intermediaries in industrial districts, in particular the mediating role universities can play within a network of companies that are interacting with one another. The focus of the research take place within a Spanish textile industrial region.

SNA in supply chains

Related to SNA in the context of supply chain systems, it is necessary to highlight the seminal work by Borgatti and Li (2009), which provides an overview of social network concepts in order to be applied in a supply chain context. Recently, Bellamy and Basole (2013) identified a growing recognition of the significant benefits a network analytic lens provide to understand, design and manage supply chain systems.

SNA techniques

Liebowitz (2005) proposes an integrative approach between the analytic hierarchy process and SNA for knowledge mapping in organizations. Caniels and Romijn (2008) use SNA to support Strategic Niche Management (SNM), an analytic technique, based on networking, learning and convergence expectations, to introduce new sustainable technologies through societal experiments. The authors review SNA contributions and elaborate a case study on an emerging biofuels sector in Tanzania.

SNA applications in health organizations

The basic concepts required to understand SNA and graph theory are collected in the work of Martinez-Lopez et al., (2009). Therefore, it is a good starting point on learning the principles and understanding SNA variables. The authors also make a review of recent applications of SNA in preventive veterinary medicine.

In the public health context, Malin et al. (2011) use open-source software to support and replicate their investigation on the study of electronic health record access logs for inferring a social network of the users and learning relational policies from these access logs. This would be a proposal to automatically collect data and infer the social network. On the other hand, Dunn and Westbrook (2011) propose a validation technique for standardised comparison of small networks in healthcare organizations. Guldbrandsson et al. (2012) use SNA in order to identify potential opinion leaders in child health promotion in Sweden. The authors collect data based on email questionnaires. Zhang et al. (2012)

combine co-word analysis and SNA techniques to analyze research literature on patient adherence in the health sector and to show their knowledge structure and evolution over time.

Collaborative platforms and social network sites

Kaplan and Haenlein (2010) and Kietzmann et al. (2011) define social network sites as virtual platforms on which people can synchronously or asynchronously create, share, modify or react to various forms of electronic content. Roberts and Candi (2014) develop an empirical research through a web-based questionnaire to 351 European companies to investigate the use of social network sites in the context of new product development and business performance in terms of innovativeness, growth and profitability. It is important to highlight several works focused on issue network tools, also known as argumentation or rationale capture technologies. For instance, the work by Gürkan et al. (2010), which develop Deliberatium, a large scale on-line argumentation platform based on collaborative technologies (IBIS and Common Lisp applications). In this sense, Natter et al. (2013) develop a self-scaling, interoperable, platform for collaborative data sharing of chronic disease registries.

Table 3 summarizes the objectives and the application context of the reviewed papers.

Table 3. Objectives and application context of the reviewed papers

Year	Author(s)	Objectives	Application context
2003	Borgatti and Foster	Literature review and analysis of organizational network research	General organizations
2005	Giuliani and Bell	To study a cluster knowledge network by focusing on the absorptive capacity of firms	Wine industry
2005	Liebowitz	Knowledge mapping in organizations	General organizations
2007	Boschma and ter Wal	To study a cluster knowledge network by focusing on the absorptive capacity and the innovative performance of firms	Footwear industry
2007	Giuliani	To explore the structural properties of knowledge networks in three wine clusters	Wine industry
2008	Caniels and Romijn	Application of SNM (Strategic Niche Management) and SNA approach to a case study about the emerging biofuels sector in Tanzania	Biofuels
2008	Giuliani and Bell	To study the evolution of a cluster knowledge network	Wine industry
2008	Morrison	To study a cluster knowledge network by focusing on the role of firms	Furniture industry

Year	Author(s)	Objectives	Application context
2008	Sammarra and Biggiero	To investigate the exchange of technological, market and managerial knowledge in an industrial cluster	Aerospace industry
2008	Winter et al.	To develop Teradata University Network (TUN), a web-based collaborative platform that provides access to teaching materials and software tools to lecturers and students	Education
2009	Borgatti and Li	Literature review of SNA and extension to supply chains	Supply chains
2009	Borgatti et al.	To provide an overview of the network analysis in the social sciences	Social Sciences
2009	Martinez-Lopez et al.	To review and apply SNA and graph theory for preventive veterinary medicine	Veterinary medicine
2009	Morrison and Rabelotti	To analyze in a cluster knowledge network the nature of the knowledge transmitted through informal contacts	Wine industry
2010	Gürkan et al.	To develop and validate a large scale on-line argumentation platform	General organizations
2010	Ramírez-Pasillas	To analyze in a cluster knowledge network the structure of friendship networks, personal and professional, moreover the role of firms participating in international trade fairs	Furniture industry
2011	Dunn and Westbrook	To bring together published case studies to demonstrate how a proposed validation technique provides a basis for standardised comparison of small networks	Health
2011	Malin et al.	To propose and validate a methodology to automatically extract healthcare organizations policies from the analysis of electronic health record access logs and discover association rules from the knowledge, mined from these access logs	Health
2012	Guldbrandsson et al.	To identify opinion leaders in child health promotion	Health
2012	Zhang et al.	To analyze research literature on patient adherence and show their knowledge structure over time	Health
2013	Bellamy and Basole	Overview of SNA for supply chains	Supply chains
2013	Capó et al.	To examine the links established by companies operating in low tech industrial districts (textiles) with universities and asses what is exactly their role	Textile industry
2013	Natter et al.	To design a self-scaling registry technology for collaborative data sharing on disease registries	Health
2014	Roberts and Candi	Survey of the use of social network sites in new product development	N P D

3.2 Research methodology

The reviewed works follow vastly differing research methodologies or approaches. The research methodology of the reviewed references are classified according to Dangayach and Desmukh (2001) based on Malhotra and Grover (1998). Classification is made in five types: (1) conceptual, basic or

fundamental concepts; (2) descriptive, explanation or description of the SNA process or content and performance measurement issues; (3) empirical, the study data were taken from existing database, literature review, case study, taxonomy or typology approaches; (4) exploratory cross-sectional, the study objective is to become more familiar by surveying at one point in time; (5) exploratory longitudinal, survey methodology where data collection is done at two points or more over time in the same organisations. Table 4 shows some research methods that were used in the reviewed works.

Table 4. Research methodology and methods

Year	Author(s)	Research methodology	Methods
2003	Borgatti and Foster	Conceptual	Descriptive and conceptual
2005	Giuliani and Bell	Empirical	Roster recall method for data collection via interviews and SNA techniques for analysing the knowledge network
2005	Liebowitz	Descriptive	Basic or fundamental concepts
2007	Boschma and Ter Wal	Empirical	Case study based on structured interviews for data collection and the roster-recall method for knowledge measuring and SNA techniques for analysing the knowledge network
2007	Giuliani	Empirical	Micro-level data from all the universe considered gathered by interviews and SNA techniques for analysing the knowledge network
2008	Caniels and Romijn	Empirical	Review of SNA contributions and a case study based on SNM and SNA techniques in a emerging biofuels sector
2008	Giuliani and Bell	Empirical Longitudinal	Roster recall method for data collection via interviews at two points of the time (2002 and 2006) and SNA techniques for analysing the knowledge network
2008	Morrison	Empirical	Case study based on interviews for leaders data collection and structured questionnaires based on an open roster method for relational data collection. SNA techniques for analysing the knowledge network
2008	Sammarra and Biggiero	Empirical	Case study based on interviews and SNA techniques
2009	Borgatti and Li	Conceptual	It is mainly conceptual, and gives examples of studies that support theories
2009	Borgatti et al.	Conceptual	It is mainly conceptual, and gives examples of studies that support theories
2009	Martinez-Lopez et al.	Empirical	Based on both a review and a case study
2009	Morrison and Rabellotti	Empirical	Case study based on structured interviews for data collection and the roster-recall method for knowledge measuring and SNA for analysing the knowledge network
2010	Gürkan et al.	Empirical	Software development based on collaborative technologies and open-source software and validation with a sample of 160 students
2010	Ramírez-Pasillas		Data collection by a survey addressing the (owner) managers

Year	Author(s)	Research methodology	Methods
		Empirical	of the firms and SNA techniques
2011	Dunn and Westbrook	Empirical	Validation of small networks for an observation-based case study involving network analysis as a comparison of observed networks patterns
2011	Malin et al.	Empirical	SNA theory and data mining
2012	Guldbrandsson et al.	Exploratory cross-sectional	Informant and snowball techniques via email questionnaires and SNA techniques
2012	Zhang et al.	Empirical	Co-word analysis and SNA techniques
2013	Bellamy and Basole	Empirical	Literature review and an integrative framework on network analysis from three perspectives: network structure or system architecture, network dynamics or system behaviour and network strategy or system policy and control
2013	Capó et al.	Empirical	Roster –recall method- involving the researchers to present to the participants/interviewees a complete list of companies who were then asked about their relationships with each of them
2013	Natter et al.	Empirical	Architecture and informatics system development
2014	Roberts and Candi	Exploratory cross-sectional	Web-based questionnaires to 351 European companies and SNA techniques

3.3 Software packages for SNA and issue networking tools

With respect to software packages for SNA, InFlow, Krackplot and NetMiner are the three leading SNA tools according to Liebowitz (2005). Other leading SNA software is: Agna, Ucinet, NetDraw, Anthropac, Classroom Sociometrics software, Fatcat, Java for Social Networks, MultiNet, Negopy, Pajek, Siena, SocioMetrica, STOCNET, and Visone.

Martinez-Lopez et al. (2009) provides a list of the ones that are open source /or mainly for academic use (Agna, Bianche, Cytoscape, FATCAT, Igraph, Iknow, KliqFinder, JUNG, Multinet, NetDraw, NEGOPY, Netvis, ORA, Pajek, PermNet, PGRAPH, Network Insight, StoCNET, STRUCTURE, VISIONE). Borgatti et al. (2009) points to UCINET (Borgatti et al. 2002) as an example of SNA specialized software. See also INSNA (2013) for getting access to these various tools. Table 5 summarizes the software and tools used by several of the reviewed papers.

Table 5. SNA software/tools used

Year	Author(s)	Software/tool
2003	Borgatti and Foster	
2005	Giuliani and Bell	Stocnet SENIA
2005	Liebowitz	Expert Choice
2007	Boschma and Ter Wal	UCINET
2007	Giuliani	---
2008	Caniels and Romijn	---
2008	Giuliani and Bell	Stocnet SENIA
2008	Morrison	
2008	Sammarra and Biggiero	UCINET
2009	Borgatti and Li	----
2009	Borgatti et al.	UCINET
2009	Martinez-Lopez et al.	
2009	Morrison and Rabelotti	UCINET
2010	Gürkan et al.	IBIS
2010	Ramírez-Pasillas	UCINET SPSS
2011	Malin et al.	
2012	Guldbrandsson et al.	Pajek
2012	Zhang et al.	KDViz
2013	Bellamy and Basole	
2013	Capó et al.	UCINET
2013	Natter et al.	
2014	Roberts and Candi	

3.4 Benefits

Benefits of SNA are as wide as its applications. Liebowitz (2005) points out the SNA usefulness combined with the analytic hierarchic process for knowledge mapping in organizations. According to Martinez-Lopez et al. (2009), SNA is a technique that offers important benefits for the assessment of epidemiological conditions, factors and forces associated with risk for human and animal disease spread. Caniels and Romijn (2008) state that SNA also allows a good insight into the morphology of

the network and its importance for innovation. Dunn and Westbrook (2011) have provided a simple method for validating small networks in healthcare organizations.

Related to the data collection methods, it is important to highlight the work by Guldbrandsson et al., (2012), who describe in detail a simple method to map influential persons with high credibility. In this sense, the works by Giuliani and Bell (2005, 2008) and Giuliani (2007) establish a methodological framework for the data collection and application of SNA techniques for analysing knowledge networks by focusing on structural properties. Others authors have utilised Giuliani's methodology by applying or extended it (Boschma and Ter Wal, 2007; Morrison, 2008; Morrison and Rabelotti 2009; and Ramírez-Pasillas 2010). In this context, the advantages of the approach adopted by Sammarra and Biggiero (2008) consist in its replicability in any inter-organizational context and its suitability for measuring inter-firm knowledge transfer by identifying the specific content of knowledge conveyed through collaborative relationships.

The results by Capó et al. (2013) show the presence of different structures within the knowledge and information networks of the districts- in line with previous findings on the role of universities in industrial districts. The university has both an importance and increased centrality as a player in the industrial network especially in terms of circulation of knowledge. Also, the implications for policy and strategy for firms and universities are highlighted.

SNA concepts are specifically related to the supply chain context by Borgatti and Li (2009): selecting nodes and ties, egonet composition, structural holes, hubs and authorities, node centrality, cohesive subgroups, equivalence, whole network properties and bipartite graphs. Related to the supply chain structure and based on SNA, Bellamy and Basole (2013) review the following node- network and link-level properties, respectively: a) centrality and power, broker relationships, clustering and embeddedness; b) density, centralization, clustering, network typologies network topologies and complexity; and c) flow type, multiplexity and strength.

Other specific SNA applications are the use of co-word analysis and SNA techniques which can reduce the reliance on subjective judgment when doing literature reviews (Zhang et al. 2012). Roberts

and Candi (2014) answer some questions about the use of social network sites for new product development.

There are other benefits that are the result of the combination of platforms or software to support learning. An example is given by Winter et al., (2008), specifically The Teradata University Network is a support instrument for educators in the field of data warehousing, business intelligence, and database and the application of such information systems for management support. For instance, the work by Gürkan et al. (2010) have provided an empirical application of an on-line large scale argumentation tool that supports the construction of shared knowledge maps. Another example is the work by Malin et al. (2011), who infer the social network through the analysis of electronic health record access logs. These studies are aligned with the necessity of applying collaborative information technologies in order to automatically access to data from large size social networks. In the same health context, Natter et al. (2013) have provided a collaborative platform for data sharing on chronic disease registries, which minimizes technical barriers to collaborate and controls the data sharing.

3.5 Disadvantages and critical points

Along the review of the selected papers, some disadvantages and critical points have been identified in a general way on the proposed or used methods.

Large size social networks

The combination of SNA and the analytic hierarchy process for knowledge mapping would have limitations in large social network maps (for instance, supply chain networks) due to the analytic hierarchy process becoming tedious (Liebowitz, 2005). Also, the computational power of available software can be a limitation for SNA applications (Martinez et al. 2009).

Data reliability and results

With respect to concrete applications of SNA, it is important to highlight that despite of their benefits when managing large network data, there are limitations in the results related to the data used. For

instance, information could be available for certain nodes and there could be a potential risk for bias in the conclusions of the study associated to the procedure used to select the nodes (Martinez et al. 2009) and also to the scope of the collection means (Zhang et al. 2012). Also, these studies are based, mainly, on perceptual data, therefore, their findings could be to some extent the outcome of subjective bias of respondents (Sammorra and Biaggiero, 2008).

Morrison (2008) and Morrison and Rabellotti (2009) advise on the scarcity of structural data in industry clusters while the relational data is easier to get available. Sammarra and Biaggiero (2008) points out the problematic of using only one informant per firm because could induce some bias when dealing with large and even medium firms. Also, the fact that respondents are of various professional roles may influence their perception of knowledge exchange.

In this sense, Malin et al. (2011) highlight also the limitations related to the reality of data re-use and even to the time frame in which such data are collected. The authors suggest improving their proposal through the incorporation of certain semantics and by restructuring the access transactions. Guldbrandsson et al. (2012), related to the informant and snowball methods through email contacts, advise about the choice of the first contacted individuals, the formulation of the e-mail message, and the use of reminders and the response time could influence the results. In this sense, Morrison (2008) points out that results from SNA case studies on cluster knowledge networks cannot be generalizaed to other clusters.

With respect to the managerial implications of SNA results, any work indicates what have happened with these results or how these results have affected companies even when the study has been carried out in two different points of the time (for instance, Giuliani and Bell, 2008). More longitudinal data collection is also claimed by Boschma and Ter Wal (2007) and Morrison and Rabellotti (2009). While Sammarra and Biggiero (2008) highlight the difficulty in measuring the knowledge integration rather than the knowledge exchange.

With regards to generalisability of results, some research only use a limited simple size. For instance, the work by Capó et al. (2013) only address a portion of the supply chain. Future research could explore the supply chain reach of the university beyond the industrial district. Also, the focus appears to be on SME's, and therefore the question on the applicability to larger organizations arises.

Metrics appropriateness

Caniëls and Romijn (2008) highlight the necessity of incorporating insights from the two main SNA perspectives, structuralism and connectionism. The first one allows a more elaborate empirical analysis of the structural network properties but provide theoretically few relevant insights on the interactions between the network processes. While the connectionism per se provides few network indicators for a systematic analysis of a network of values tied. Also, other limitation indicated by Dunn and Westbrook (2011) is related to the appropriateness of the metrics chosen.

Supply chain

In the supply chain context, despite of Borgatti and Li (2009) define some criteria to define nodes and ties and also to collect supply network data, there is not, until the present, a validated tool or methodology for doing it. Published questionnaires/forms to the respect would be useful for readers. Also, real world applications of SNA in this supply chain context are scarce (Bellami and Basole, 2013). Furthermore, although some theoretical integrative framework on network analysis in the supply chain context is proposed in the literature (Bellamy and Basole, 2013), they are not validated.

Platform developments

Related to collaborative platforms, the results of using Deliberatium indicate that: major design efforts are needed to lower moderation costs in the use of this collaborative platforms; it is necessary for improvement of the knowledge representation; and a disproportionate use of extrinsic incentives were given (Gürkan et al. 2010). Other survey-based researches have been carried out in order to analyse the use of social network sites, for instance, in new product development (Roberts and Candi, 2014). In this case, important considerations as the market target may be incorporated in future studies. Also, Roberts and Candi (2014) identify the necessity of future research on how businesses can develop strategies to help customers connect at the same time of achieving their business goals, given that social network sites were designed primarily for connecting people rather than for commercial purposes.

4. Discussion and further research

During this review, we have identified the following gaps and aspects to consider in the KNOWNET Project for development of the research. There is a requirement to explore SNA applications to more industrial sectors, with the health as being the most studied of all sectors. Not all papers indicate the data collection methods. Not many papers use automatic data collection. There exist many problems with the data reliability and its time window. The use of an online platform to generate some of the data versus the traditional approaches adopted would be profitable in order to provide more reliability of SNA results. Managerial implications of the results of these studies even when these studies have been developed over two points at the time, are not explored sufficiently. A methodology for automatically data collection and choosing metrics would be welcome. The dynamics of networks is still little explored; hence, an effort in collecting longitudinal data on inter-firm collaboration within clusters is highly welcome (Morrison and Rabellotti, 2009). We have reviewed only the work by Giuliani and Bell (2008) which collects longitudinal data on two points of the time. The Dynamic Network Analysis by Carly 2003 based on terrorist organizations would be a starting point to apply in knowledge networking.

Finally, what is also timely is to investigate how knowledge properties may influence the process of inter-firm transfer of technological, market and managerial knowledge (Sammorra and Biaggiero, 2008).

5. Conclusions

This study has presented an overview of SNA applications in knowledge networks, which is one of the main fields using SNA close to health and security sectors. In this context, large size social networks and data reliability and results are the main limitations of the reviewed papers. We can conclude that not all papers indicate the data collection methods and not many papers use automatic data collection. Thus, there is a need for the use of an online platform to generate some of the data versus the approach adopted is an identified further avenue for research. Also, we have identified some problems relating to data reliability and its time window. In a general way, it is not indicated the managerial implications of the results of these studies for organizations and even when these studies have been developed over two points at the time.

From the identified gaps arise the following further research: (i) Methodology for automatically data collection and choosing metrics; (ii) studies about the impact in organizations on SNA studies. For instance, there are not quantifications of the benefits of these studies for organizations apart from the structure/connections picture of the networks and some recommendations of behaviouring; (iii) the dynamics of the networks is still little explored; hence, an effort in collecting longitudinal data on inter-firm collaboration within clusters is highly welcome (Morrison and Rabellotti, 2009). We have reviewed only the work by Giuliani and Bell (2008) which collects longitudinal data on two points of the time. Here, the proposal of a dynamic network analysis by Carley (2003) focused on terrorist organizations, is an approach to consider in knowledge networking systems; and (iv) to investigate how knowledge properties may influence the process of inter-firm transfer of technological, market and managerial knowledge (Sammorra and Biaggiero, 2008).

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