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An overview of social network analysis and knowledge networks

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Abstract This paper presents an extract of a more extensive review of the literature on immersive social networking systems and social network analysis (SNA). The paper overviews the current literature on relevant knowledge networking models. There is a special interest in SNA applications in knowledge management. The result of this paper is a report describing the main findings of some knowledge networking models and SNA.

Key words: Social network analysis, knowledge networks, knowledge management.

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).
Social network analysis (SNA) provides researchers with 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). 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). As decision support tools to support sustainability that is highly dependent on understanding communities and individuals (e.g., environmental justice analysis, sustainable transportation organizations), SNA can help identify key players, influencers, and trusted groups within a community.
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

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systems and SNA; (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 presents the reviewed papers based on their objectives and applications, used tools, advantages and disadvantages. Section 4 discusses the main findings and future research opportunities. Section 5 presents a conclusion to the study.

2. Review methodology

The literature review was carried out 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 focuses of the selected references were SNA and its applications on knowledge networks. 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. Here, an extract of the more extensive literature review is presented by highlighting the main aspects related to knowledge networks.

3. SNA and knowledge networks

3.1 Context and objectives

Borgatti and Foster (2003) establish 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 knowledge networks continue being one of the main fields for SNA applications.

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 in time.

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 on a case study in an emerging biofuels sector in Tanzania.

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.

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'. This is supported by Morrison and Rabelloti (2009) who 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.

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 an a supply chain context. Recently, Bellamy and Basole (2013) identify a growing recognition of the significant benefits a network analytic lens provide to understand, design and manage supply chain systems.

3.2 Software packages for SNA and issue networking tools

With respect to software packages for SNA, InFlow, Krackplot and NetMiner are three of the 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, NetMiner, Pajek, Siena, SocioMetrica, STOCNET, and Visone.

Martinez-Lopez et al. (2009) provides a list of the ones that are free or 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 out UCINET (Borgatti et al. 2002) as an example of SNA specialized software. See also INSNA (2013) for getting access to these various tools.

3.3 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 Caniels and Romijn (2008), SNA also allows a good insight into the morphology of the network and its importance for innovation.

Related to the data collection methods, it is important to highlight the works by Giuliani and Bell (2005, 2008) and Giuliani (2007) who 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 considered Giuliani's methodology by applying or extended it (Boschma and Ter Wal, 2007; Morrison, 2008; Morrison and Rabellotti 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. 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 embeddeness; b) density, centralization, clustering, network typologies network topologies and complecity; and c) flow type, multiplexity and strength.

3.4 Disadvantages and critical points

Some disadvantages and critical points have been identified in a general way on the proposed or used methods.

The combination of SNA and the analytic hierachy process for knowledge mapping would have limitations in large social network maps (for instance, supply chain networks) due to the analityc hierarchy process could become tedious (Liebowitz, 2005).

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, these studies are based, mainly, on perceptual data, therefore, their findings could be to some extent the outcome of subjective bias of respondents (Sammarra 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. Sammarra and Biaggiero (2008) point out the problem of using only one informant per firm, because this could induce some bias when dealing with large and even medium sized firms. Also, the fact that respondents are of various professional roles may influence their perception of knowledge exchange. In this sense, Morrison (2008) points outs that results from SNA case studies on cluster knowledge networks cannot be generalizaed to other clusters. Regarding the generalisability of results, some relate to 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 in on SME's, but the question on the applicability of the findings to larger organizations must be considered.
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). 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 to measure the knowledge integration rather than the knowledge exchange.
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 tied values.
In the supply chain context, Borgatti and Li (2009) define some criteria to define nodes and ties and also to collect supply network data but there is not, until recently, a validated tool or methodology for doing it. Published questionnaries/forms to the respect would be useful for researchers. 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), although this is not validated.

4. Conclusions and further research

This paper has presented an overview of SNA applications in knowledge networks, which is one of the main fields using SNA similar to health and the security sector. 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, the use of an online platform to generate some of the data versus the approach adopted, is a promising area for further research. Also, we have identified some problems to solve with the data reliability and its time window. In a general way, the managerial implications of the results of SNA studies for organizations are not highlighted even when these studies have been developed over two points in 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 example, 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 behaviour; (iii) the dynamics of the networks is still little explored; hence, an effort in collecting longitudinal data on inter-firm collaboration within clusters would be highly welcome (Morrison and Rabellotti, 2009). We have reviewed only the work by Giuliani and Bell (2008) which collects longitudinal data at two points in time. Here, the proposal of a dynamic network analysis by Carley and (2003), focusing 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 (Sammarra and Biaggiero, 2008).

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