

Managing supply chain knowledge in the new product development process: a social network analysis approach

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Abstract – The aim of this paper is to propose a conceptual framework for studying the knowledge transfer problem within the supply chain. The social network analysis (SNA) is presented as a useful tool to study knowledge networks within supply chain, to visualize knowledge flows and to identify the accumulating knowledge nodes of the networks.

Keywords – New Product Development, Knowledge Management, Supply Chain, Social Network Analysis.

I. INTRODUCTION

It had become broadly acknowledged that contemporary firms deem the opportunity of involving external sources of innovation, such as suppliers, in the new product development process (NPD) [1] [2]. The importance of integrating complex and widely dispersed sources of knowledge between a firm and its strategic business partners is increasing popular [3] [4] [5]. In fact the emerging knowledge-based view of the firm, which built on tenets of the resource-based view, suggested the importance of integrating the specialist knowledge of each member to produce new products and services [6].

At the same time, the complex nature of the NPD process and the main difficulties experienced by organizations, are widely recognized in the literature [7]. Such complex integration process has consequences on the knowledge management of the firm as well as on its organizational asset, leading to vertical disintegration, modularization and networking [8]. In fact, the occurring of networking phenomena and collaboration across firms through complex supply chain has been pointed out by MacDuffie and Helper [9]. In such a context, Sanchez [10] argued that “managers need to understand not just the stock of knowledge but also how to manage the actual and potential transfers and diffusions (flows) of knowledge within and across the boundaries of the organization”. The necessity of mapping these knowledge flows has become urgent for both scholars and practitioners. Involving external sources of innovation in the NPD process showed different problems. One of the main problems in the NPD process is the understanding of how people located in different hubs works together. The risks related to this aspect for a firm is to lose the chance to experience the learning by doing opportunities that every hub experienced. In the light of this, the risk of losing important knowledge asset is always present in

coordinating and managing the NPD process between a firm and its external knowledge suppliers located in different countries or in different hubs. Reasoning from this perspective this paper aims to investigate the role of players outside the firm’s boundaries, because we maintain that these aspects are particularly critical and difficult to manage in the development of complex products. The trade off between complex product innovation and the risk of knowledge erosion and obsolescence will be investigated through the lens of the classical categories of exploitation and exploration. The knowledge erosion problem relates to experience and knowledge accumulation processes [11]. In this paper we tackle the issues related to the supply chain context seen as a network and the challenge of integrating the specialist knowledge into the NPD process by using the social network analysis (SNA) methodology, which allows us in mapping the actual knowledge flows across the supply chain. This study provides both academics and practitioners in understanding the actual organizational assets and their interactions with the product innovation process, focusing the attention on the knowledge transfer problem.

The paper is organized as follow. Section 2 discusses the literature review and identifies the research gap. Section 3 presents the methodology of SNA. Section 4 describes the procedure used for knowledge network mapping. Finally, section 5 concludes the paper.

II. LITERATURE REVIEW

For a long period, operation researchers assumed that organizations should adhere to proven process template, replicating the same organizational routines [12] to improve their efficiency [13]. More recently it has been acknowledged that such a strategy could render organizations rigid and unable to learning and innovate. This represents a classical problem about the trade off between routinization and innovation, which can be seen through the lens of the knowledge management approach to exploitation and exploration practices [14] [15]. They are two intertwined activities, but the literature tends to differentiate them by identifying the first as an information and knowledge sharing activity, and the second as a knowledge development one. The first categorization relates more to those knowledge management practices based on the information and communication technology (ICT) solutions, the second is

more based on a relational view, that enhances social aspects such as communities of practices (CoPs) or trust and commitment to develop new knowledge [16] [17]. Firms seem to be always unsteady balance between exploration and exploitation. The distinction between the two forms remains a complicated dilemma and literature suggests that organizations tend to favour exploitation over exploration [18]. The intertwined nature of exploitation and exploration is showed by the assumption that “low level exploration can co-exist with high-level exploitation” [19]. The two are complementary rather than a dichotomy. In fact Winter [20] posited that structured and systemic innovation might render exploration and exploitation complementary. Despite these suggestions it remains very difficult for the organizations to maintain a balance.

In the NPD process the need to implement knowledge management activities that enhance both exploitation and innovation is particularly crucial. In fact, it is an area in which firms have to continuously cooperate in order to share knowledge, and knowledge management activities have to be developed. The literature review conducted by Corso et al. [21] on knowledge management in product innovation described NPD as a continuous learning process rather than a sporadic event and showed it as one of the most promising areas where knowledge management could be applied. Corso and Paolucci [22] included the NPD as a part of their analysis on the relationship between the knowledge transfer processes and ICT applications. Their results are in line with the extant literature, showing that ICT solutions can enhance the transfer of knowledge, but have no impact on the knowledge development. Becker and Zirpoli [23] included the product innovation process as part of their investigation into outsourcing in FIAT auto. They suggested that “the central challenge in the organization of the NPD process is how to integrate and co-ordinate the specialist knowledge and competences of the participants in the NPD process” [23]. Chen et al.’s [24] focused the attention on the social dimension of knowledge exchange and highlighted the use of KM methods such as informal meeting, experience workshops and expert interviews to ensure the NPD process. We can summarize that the extant literature is focused on the exploitation process in the NPD. Our paper aims to fill this gap, studying both exploitation and exploration in the NPD context.

III. METHODOLOGY

Herein, we propose the use of SNA because it is a useful tool for practitioners and scholars to inquire into the relationships among a social network. We selected the SNA as methodology for mapping knowledge flows in the supply chain context for three reasons. First, the supply chain is usually considered as a set of elements related to vertical transactions between partners. Second, the SNA relates to the informal dimension of relationships

underpinning the formal agreements between different actors. The combination of these two approaches can provide academics and practitioners to a more holistic view of relations across the supply chain highlighting the informal dimension of inter-organizational relations such as those based on knowledge exchanges. Third, we assume that the SNA approach allows the monitoring of both exploitation and exploration in the NPD.

Examples of a social network can be friendships among groups as well as business relations between companies. The main aspect in a social network is the existence of connections, ties, among actors or nodes of the network. In a business framework the social network perspective posits that all organizations are social networks, that the environment is a network of other organizations. In a supply chain network perspective, such interpretation of the context can provide new insights. Moreover, in the social network field, the study of the features of ties has many implications for the study of knowledge. Following Burt [25], ties can be studied for their access, timing, and referrals. Access deals with the chance given by certain network ties, to have influence on someone in the network. Timing regards the chance to save time in obtaining information through some connections. Referrals mean the opportunities given by some connections.

In social network studies, there are two main streams of research regarding information and knowledge access. One is consistent with the structural hole theory, the other with the social capital theory. According to the structural hole theory, emphasis is on the central nodes of the network because they have multiple connections and more chances to gain access to important knowledge and information than peripheral nodes. The important aspect to specify is that central nodes emerge after SNA. They do not dovetail with those indicated by formal structure. On the other hand, the social capital theory is more concerned with the social relationships in which actors are embedded. The main tenet is that social connections have a positive impact on individual growth. Mathematical studies and methods for modelling networks highlighted features of network structure [26] [27] and its statistical properties. The first property is “small-world”, the second is clustering, whereas the third is the property of having a skewed degree distribution [28]. In recent years there has been a growing interest in SNA discipline and it emerges as an interdisciplinary domain and for this reason it has become very attractive for statisticians, mathematicians, sociologists and biologists. The first significant contribution in this field is by researchers of the School of Manchester. Thanks to their reflections, “network” is discussed, for the first time, as an analytical concept to which the mathematical theory of graphs can be applied.

SNA involves a new point of view of social relationships. It abandons an atomistic perspective to look at the network of relationships among actors. The actor is no longer a point of interest in SNA perspective. This is the main reason to propose a social network approach in the study of knowledge transfer. Since knowledge transfer

among different partners needs trust and common commitment, SNA appears a useful tool to identify where such characteristics exist among groups. SNA perspective emphasizes the importance of relationships, and above all, it looks at the informal connections. Generally the informal network, identifiable through SNA, seems to be the best place in which trust and therefore learning takes place [29]. In the literature SNA applications are used to improve flows of knowledge, to find lack of connections and to understand the nature of social ties and the degree of their intensity [29]. Indeed the main assumption is that knowledge passes more easily across informal ties than through formal links. If knowledge is embedded in a network of relationships, in the interaction of people, tools, and tasks SNA is a useful tool to inquire how the network is structured, who the more embedded nodes of the network are, and how to reach knowledge which is accumulated and embedded in those relationships.

SNA is a tool to visualize the map of knowledge flows. The main potential of SNA is its capacity to visualize relationships, and monitor information and knowledge flows [30]. SNA is able to represent the relationship structure through a graph on which it is possible to do quantitative and qualitative analysis. The growing attention to the informal dimension of an organization is due to at least two factors. First, the evidence provided by many researchers that knowledge flows more easily through informal relationships than following formal organizational structure [31]. The second aspect is the extensive introduction of ICT in the companies that have made their boundaries more permeable than before. Through ICT, communication and information pass across firm's boundaries allowing connections among people residing in different subunits of the same company, or even among units located far from the others. For all these reasons we propose SNA as a strategic tool for management in order to gain innovative inputs from firm strategic suppliers. Most of the applications of SNA in the management field deal with the comparison between formal organizational structure and the informal one, which emerges thanks to SNA application.

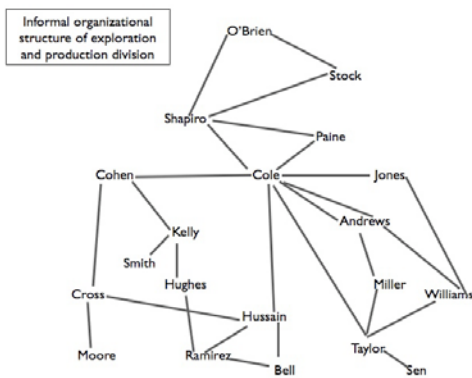


Fig. 1. Example of an informal network (adapted by Cross and Parker, 2001)

Generally, the aim of the comparison is to reveal that individuals less considered in the formal structure are, in contrast, central in the informal network of relationships. Fig. 1 shows an example of an informal network in which the person identified as the most central in the group is placed at the centre of the network. The central node is the node with most connection in the network.

SNA emerges as a set of methods for the analysis of social structures through a specific investigation of the relational aspects of these structures. The use of these methods, therefore, depends on the availability of relational rather than attribute data. Relational data analysis is made by ordering the information in matrix: a framework in which each agent is listed twice (case-by-case matrix) once in the rows and once in the columns. The presence or absence of connections between a pair of agents is represented by “1” or “0” entries in the appropriate cells of the matrix. Then, the matrix describing the relations among actors can be converted into a graph of points connected by lines, called name sociogram, in which each line indicates the information link between two people; the arrow represents the direction of the relationship (incoming arrows show that the person is a source of information; outgoing arrows mean that the team member seeks information from the linked party). Other indications include a) Central people: who the most prominent people within a group are; b) peripheral people: some people are only loosely connected to a network; c) Subgroups: groups within a group often arise along lines of location, function, hierarchy, tenure, age or gender.

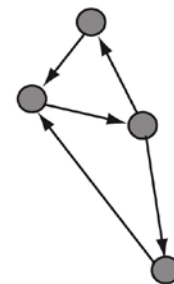


Fig. 2. Example of a sociogram (adapted from Kilduff and Tsai, 2003)

There are two ways to study the network. One is called egocentric, while the other one is bounded [29]. In the first type, the egocentric, the researcher starts to collect data from one person. This person identifies the other people who are important for the specific purpose in building network. The purpose can be to identify the most central node of the informal network, or the leader of the team group and so on. According to Cross et al. [29] the main advantage of an egocentric network analysis is that it can uncover all the important relationships for the person taken into account. Generally it is based on short surveys. On the other hand the bounded network approach implies the identification of a network of

interest. It can be a division, such as the R&D group or quality control department of a firm. In this case the researcher has to survey each person of the group about his relations with the others of that group. In the case of a supply chain network application, the use of a network bounded approach can help the researcher to identify the most peripheral groups within supply chain, in terms of their connections with the others of the same chain.

IV. CONCEPTUAL FRAMEWORK

We selected to adopt a bounded approach, thus we selected a network of interest. Usually this step should be decided by discussing with managers, but in our case we decided ex ante to study the NPD group. Following Cross and Parker's [29] work on SNA, we designed a questionnaire in order to map the actual knowledge flows across the supply chain and to identify the accumulating knowledge nodes. Respondents have been asked to identify their external strategic partners and to whom they most often turn to their daily work activities, or to whom they typically turn to for help in thinking a new or challenging problem.

Drawing on the concept of knowledge networks discussed by Hansen [34], we aimed to identify the knowledge network within the supply chain of a firm belonging to the automotive industry. We have chosen the automotive because it is a complex product industry with multiple players involved in the innovation process.

The questionnaire has been created in order to identify and visualize the knowledge network on which the NPD group rely on, across the supply chain and the accumulating knowledge nodes embedded in the knowledge network. These central nodes can be individuals as well as entire groups on which the rest of the organization relies to acquire important knowledge. The notion of accumulating knowledge nodes further expands the previous studies on the problem of experience and knowledge accumulation, which remain one of the most critical aspects to further investigate.

The data collection activity included the post-test interviews that have been conducted after the analysis of the quantitative data gathered through the questionnaire.

TABLE I – PROCEDURE AND WORK FLOW

Step 1	Designing the SNA questionnaire
Step 2	Identifying the network of interest
Step 3	Submit the SNA questionnaire
Step 4	Data collection
Step 5	Knowledge network mapping
Step 6	Post-test interviews
Step 7	Sharing results with participants

V. CONCLUSION

The NPD is a crucial process for a firm that have to collaborate with multiple knowledge suppliers. The

integration of different knowledge flows across the supply chain is the one of the main challenge to face up. Starting from this point we tried to identify knowledge networks and the accumulating knowledge nodes. The main advantage of this study is the chance to know where firm-specific knowledge is located and to foster its transfer within the chain.

This work was designed to be exploratory and was based on a single case study. Future work is expected to provide more generalized findings on the relation between the management of knowledge network within the supply chain and its capacity to improve the knowledge management process in the overall supply chain.

The extant literature showed that knowledge management is considered as a tool for supply chain integration. Despite the interest in studying ICT solutions for improving knowledge sharing, the evidence of a positive relationship between their use and the success of supply chain integration is weak. Furthermore, as we already mentioned, the knowledge management literature shows that the knowledge accumulation problem remains one of the most important aspects to study. Our paper is in line with previous research on knowledge management in supply chain and has important implications. In particular, some literature suggested the need of organizational solutions more than technical ones (Becker, 2001; Edwards et al., 2005). The main implication of an SNA application in the supply chain relates to knowledge management and organizational aspects. First, the implementation of a SNA analysis provides managers with important information on the characteristics of the network under analysis. More specifically, we can understand the degree of connection, density and cohesion of the organizational knowledge network, within which the knowledge transfer and development takes place. Thus, the study can contribute to the understanding of how firms create knowledge across their supply chain, and how firms can enhance their efficiency and effectiveness, which are the most critical factors in the NPD processes.

REFERENCES

- [1] K.B. Clark, "Project scope and project performance: the effect on parts strategy and supplier involvement in product development," *Management Science*, vol. 35, no. 10, pp. 1247-1263, Oct. 1989.
- [2] T. Nishiguchi, *Strategic Industrial Sourcing*. New York: Oxford University Press, 1994.
- [3] J.F. Christensen, "Wither core competency for the large corporation in an open innovation world?" in *Open Innovation: Researching a New Paradigm*, Chesbrough, H., Vanhaverbeke, W. and West, J., Oxford: Oxford University Press, 2006, ch. 3, pp. 35-61.
- [4] H. Chesbrough, *Open Innovation*. New York: Free Press, 2003, pp. 15-30.

- [5] H. Chesbrough, W. Vanhaverbeke, and J. West, *Open Innovation: Researching a New Paradigm*, Oxford: Oxford University Press, 2006, pp. 20-30.
- [6] R. Grant, "Towards a knowledge-based view of the firm," *Strategic Management Journal*, vol. 17, no. Winter Special Issue, pp. 109-122, Jan. 1996.
- [7] F. Wynstra, A. van Weele and M. Weggeman, "Managing supplier involvement in product development: Three critical issues," *European Management Journal*, vol. 19, no. 2, pp. 157-167, Apr. 2001.
- [8] T.J. Sturgeon, "Modular production networks. A new American model of industrial organization," *Industrial and Corporate Change*, vol. 11, no. 3, pp. 451-496, Apr. 2002.
- [9] J.P. MacDuffie and S. Helper, "Collaboration in supply chains. Whit and without trust," in *The Firm as a Collaborative Community*, C. Heckscher and P. Adler, Oxford: Oxford University Press, 2010, ch. 10, pp. 417-466.
- [10] R. Sanchez, "Managing Articulated Knowledge in Competence-based Competition," in: *Strategic Learning and Knowledge Management*, R. Sanchez & A. Heene, Chichester: John Wiley, 1997, ch. 4, pp. 163-187.
- [11] M. Zollo, and S.G. Winter, "Deliberate learning and the evolution of dynamic capabilities," in *The Blackwell Handbook of Organizational Learning and Knowledge Management*, M. Esterby-Smith, M.A. Lyles, Blackwell Publishing, 2003, ch. 30, pp. 601-622.
- [12] W.E. Deming, *Out of the crisis*. Massachusetts Institute of Technology, centre for Advances Engineering Study, Cambridge Mass. 1986.
- [13] R.R. Nelson, S.G. Winter, *An Evolutionary Theory of Economic Change*. Belknap Press, Cambridge, MA, 1982.
- [14] J.G. March, "Exploration and exploitation in organizational learning," *Organization Science*, vol. 2, no. 1, pp. 71-87, Feb. 1991.
- [15] P.H. Gray, "A problem-solving perspective on knowledge management practices," *Decision Support Systems*, vol. 31, no. 1, pp. 87-102, Mar. 2001.
- [16] J.S. Brown, and P. Duguid, P., "Knowledge and organization: A social-practice perspective," *Organization Science*, vol. 12, no. 2, pp.198-213, Feb. 2001.
- [17] M.T. Hansen, N. Nohria, and T. Tierney, "What's your strategy for managing knowledge?," *Harvard Business Review*, vol. 77, no. 2, pp. 106-116, Nov. 1999.
- [18] D.A. Levinthal, and J.G. March, "The myopia of learning," *Strategic Management Journal*, vol. 14, no. 2, Feb. pp. 95-112, 1993.
- [19] P.S. Adler, M. Benner, J.P. MacDuffie, E. Osono, B.R. Staats, H. Takeuchi, M. Tushman and S.G. Winter, "Perspectives on the productivity dilemma," *Journal of Operations Management*, vol. 27, no. 2, pp. 99-113, Feb. 2009..
- [20] S.G. Winter, "Understanding dynamic capabilities," *Strategic Management Journal*, vol. 24, no. 10, pp. 991-995, Oct. 2003.
- [21] M. Corso, A. Martini, E. Paolucci and L. Pellegrini, "Knowledge management in product innovation: an interpretative review," *International Journal of Management Reviews*, vol. 3, no. 4, pp. 341-35, Oct. 2001.
- [22] M. Corso, and E. Paolucci, "Fostering innovation and knowledge transfer in product development through Information Technology," *International Journal of Technology Management*, vol. 22, no. 1/3, pp. 126-148, Nov. 2001.
- [23] M.C. Becker and F. Zirpoli, "Organizing new product development. Knowledge hollowing-out and knowledge integration - the FIAT Autocase," *International Journal of Operations & Production Management*, vol. 23, no. 9, pp. 1033-1061, Sept. 2003.
- [24] H.H. Chen, H. Kang, X. Xing, H.I.A. Lee and Y. Tong, "Developing new products with knowledge management methods and process development management in a network," *Computer in Industry*, Vol. 59, No. 1-3, pp. 242-253, Mar. 2008.
- [25] R.S. Burt, *Structural Holes: The Social Structure of Competition*. Cambridge, MA: Harvard University Press, 1992.
- [26] de S. Pool, and I. M. Kochen, "Contacts and influence," *Social Network* vol. 1, no. 1, pp. 1-48, Nov. 1978.
- [27] S. Milgram. "The small world problem," *Psychology Today*, vol. 11, pp. 60-67, May 1967.
- [28] A. Barabasi, (Albert R, Jeong H, Barabási AL, "Internet—diameter of the World-Wide Web," *Nature* 401[6749]: pp. 130-1, 9 Sept.1999.
- [29] R. Cross, and A. Parker, *The hidden power of social networks*. Harvard Business School Press, Boston Massachusetts, 2001.
- [30] M. Kilduff, and W. Tsai, *Social Networks and Organizations*, Sage London 2003.
- [31] J. Allen, A. James, and P. Gamlen, "Formal versus informal knowledge networks in R&D: a case study using social network analysis," *R&D Management*, vol. 37, no. 3, pp. 179-196, Jun. 2007.
- [32] M.T. Hansen, "Knowledge networks: explaining effective knowledge sharing in multiunit's companies," *Organization Science*, vol. 13, no. 3, pp. 232-248, Marc. 2002.