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Structural social capital and innovation. Is knowledge transfer the missing link?

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Abstract

Purpose - R&D people, business units, and organisations are becoming increasingly involved in collaboration networks to share knowledge and generate innovation more effectively than in the past. The social capital theory has been adopted in several areas of study to explain how individuals, groups, and businesses manage relationships to generate better innovation outputs. However, research has obtained contrasting results about the contribution of distinct structural configurations of social capital to innovation. To shed light on such relationship, the current paper reviews the literature on structural social capital, knowledge types and knowledge transfer processes, and innovation at the interpersonal, inter-unit, and inter-firm levels.

Design/methodology/approach - This review has considered studies on social capital in organisational behaviour, strategy, and management over a period of 20 years.

Findings – This study emphasises the importance of knowledge transfer processes and of knowledge types as mediators in the relationship between structural social capital and innovation. Moreover, results at the different levels of analysis provide support that seemingly opposite configurations of social capital are complementary to each other (structural holes *vs.* dense networks, strong *vs.* weak ties ties). Accordingly, the balance of different configurations of social capital enables the ego to explore, access, assimilate, and combine different knowledge types, which ultimately lead to higher innovation performance.

Originality/value – This review enables to understand the mediating role of knowledge transfer processes and knowledge types in the relationship between structural social capital and innovation.

Keywords: structural social capital; network size; tie strength; network configuration; centrality; knowledge transfer processes; knowledge types; innovation; knowledge-based view; literature review.

Introduction

The knowledge-based view of the firm recognises the centrality of knowledge and its management as the main enablers of a firm's competitive advantage (Nonaka, 1991; Grant, 1996; Argote and Ingram, 2000). However, companies and their employees do not always possess the necessary knowledge to innovate within their boundaries; therefore, they cross boundaries to learn from strategic alliances and other forms of collaborations. To compete in the global knowledge-economy, people and firms are urged to continuously search, access, and exploit external knowledge, which is provided by different typologies of actors, such as business partners, customers, suppliers, universities, and competing firms. Research has found that the process of transferring knowledge from one organisation to another or from one person to another is considered to be a vital process for organisational effectiveness and for innovation generation (Kogut and Zander, 1992; Powell, Koput and Smith-Doerr, 1996; Dyer and Nobeoka, 2000; Argote and Ingram, 2000; Lane, Salk and Lyles, 2001). Business networks have emerged as the new locus where firms of different sizes share knowledge and generate innovations more effectively and efficiently than in the past (e.g., Powell *et al.*, 1996; Owen-Smith and Powell, 2004; Shu *et al.*, 2012). The rising importance of business and individual relationships for the acquisition of valuable knowledge demands a thorough understanding of the way that companies and individuals orchestrate these relationships to facilitate knowledge flows and to optimise innovation outputs.

Social Capital (SC) is particularly important for businesses and personal networks because it enhances knowledge transfer (Adler and Kwon, 2002; Inkpen and Tsang, 2005). SC has been defined as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit" (Nahapiet and Ghoshal, 1998, p. 243). SC theory is increasingly attracting the interest of scholars across a number of disciplines (Adler and Kwon, 2002); however, these studies have often produced partial or

contrasting results about the role of SC for improving innovation performance (McFadyen and Cannella, 2004; Rodan and Galunic, 2004; Obstfeld, 2005; Moran, 2005; Molina-Morales and Martínez-Fernández, 2009; Tortoriello and Krackhardt, 2010; Maurer, Bartsch and Ebers, 2011). These contrasting results might be determined by the fact that former SC studies often did not consider the type of resources and of the exchange processes that would enable SC to achieve its innovation goals. In this study we focus on the structural dimension of SC and we attempt to highlight the importance of knowledge exchange processes and of different knowledge types as mediating factors in the relationship between SC and innovation. The goal of this review is to understand if and how the different dimensions of structural SC influence the transfer of different knowledge resources which, subsequently, will affect innovation at the intra- and inter-organisational levels. The current paper has reviewed this literature covering a period of 20 years in relation to three areas of study: management, strategy, and organisational behaviour.

Knowledge and Knowledge Transfer Processes

The competitive environment evolves rapidly and the capacity to manage knowledge-based intellect is the most critical capability in the current knowledge-based economy (Quinn, 1992). The knowledge-based view of the firm assumes that the wealth-creating capacity of enterprises is mainly situated on the knowledge and capabilities that they acquire and retain. Knowledge is an intangible asset, and its management is more complex than managing information or any other physical asset such as machineries, raw materials, industrial establishments, and the like. Davenport and Prusak define knowledge as "a fluid mix of framed experiences, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information…(which) often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices, and norms" (1998, p. 5). Knowledge is considered to be the raw material of innovation, and the transfer of knowledge within and between organisations

and individuals is considered to be a source of innovation (Cohen and Levinthal, 1990; Kogut and Zander, 1992; Powell *et al.*, 1996; Dyer and Nobeoka, 2000; Tsai, 2001; Lane *et al.*, 2001; McEvily and Marcus, 2005). In fact, innovations emerge when individuals and organisations discuss and combine pieces of existing knowledge in an innovative way (Cohen and Levinthal, 1990; Henderson and Clark, 1990; Kogut and Zander, 1992). Knowledge transfer has been defined as the process through which a piece of knowledge is acquired in one situation and it is applied to another (Argote and Ingram 2000). However, different scholars have conceptualised knowledge transfer differently (see Table 1).

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Drawing on these definitions, the processes presented in table 2 have been used to refer to KT.

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Knowledge creation is one of the most relevant outputs of KT activities and refers to new knowledge in terms of new products, processes, skills or capabilities resulting from the combination of existing knowledge. The knowledge management literature identifies two ways of sharing knowledge in inter-firm relations; namely *exploitation*, when firms deploy existing knowledge to create value; and *exploration*, which occurs when companies engage in learning activities aimed at the development of entirely new products and services, such as breakthrough innovations (March, 1991). While knowledge exploration has a long-term horizon and refers to a generation of new knowledge, knowledge exploitation has a short-term orientation and refers to the adoption of existing knowledge to generate incremental innovations (Grant and Baden-Fuller, 2004).

Social Capital in Managerial Studies

The SC theory has been developed by a group of sociologists in the mid-1980s (Bourdieu, 1985; Coleman, 1988, 1990; Burt, 1992; Putnam, 1993). The origins and definitions of SC have been

widely discussed by other authors in theoretical papers (Nahapiet and Ghoshal, 1998; Adler and Kwon, 2002; Inkpen and Tsang, 2005; Alguezaui and Filieri, 2010). One of the difficulties in dealing with SC theory is the number of definitions of the concept, which have fostered disparate approaches. However, there is a general agreement that SC represents the social relationship of ego (individual or collective) and the resources ego access through social relationships (Lin, 2001). Drawing on Coleman's conceptualisation of SC (1988), Nahapiet and Ghoshal introduced SC in business studies by defining it as: "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit" (1998, p. 243). SC refers to the set of resources, both tangible and intangible, which may be easily and rapidly available to the ego (individual, business unit, focal firm) within a certain network configuration (*structural SC*), but it also refers to good relations with *the alter* (*relational SC*), and a shared intellectual background (*cognitive SC*) (Nahapiet and Ghoshal, 1998).

The SC concept posits that social relationships enhance the sharing of different typologies of resources, which enable the attainment of goals, which cannot be otherwise achieved without such relationships. Through SC businesses can access complex, new, and costly knowledge, which is needed to create new products that better respond to the customer's needs (Alguezaui and Filieri, 2010). SC helps businesses to obtain new knowledge by affecting conditions enabling new knowledge acquisition and knowledge recombination (Inkpen and Tsang, 2005), which may lead to innovation (Henderson and Clark, 1990).

The existing managerial literature lacks a thorough review of studies that have investigated the impact of different dimensions of structural SC on KT processes, and on the transfer of different knowledge types (e.g., tacit *vs.* explicit). Accordingly, in this paper we review such literature with an attempt to analyse whether the knowledge resource exchanged through social relations and the transfer processes adopted are critical mediators in the relationship between structural SC and innovation at both the intra-firm (inter-personal and inter-unit) and inter-firm levels.

Methodology

We conducted a thorough literature review of the empirical and theoretical studies on structural SC, knowledge transfer and creation, and innovation covering a period of almost 20 years, from 1992 to 2012. Our research was focused on the papers published in top journals in management, strategy, and organisational behaviour (Ranking of Association of Business Schools, 2010). Some important studies on the topic of SC, KT, and innovation published in leading sociology (e.g., *American Journal of Sociology*), marketing (e.g., *Industrial Marketing Management*), and innovation journals (e.g., *Journal of Product Innovation Management*) were included as well.

We have retrieved for journal articles by using the following keywords: *structural social capital, cohesive (and closed) networks, dense (and sparse) networks, centrality, network size, strong ties, weak ties, knowledge transfer, knowledge sharing, knowledge search, knowledge access, knowledge acquisition, knowledge assimilation, knowledge integration, knowledge creation, knowledge exploration, knowledge exploitation, knowledge combination,* and *innovation* in the main business databases (e.g., Ebsco). This research produced a list of over 1,000 titles. The abstract of every paper was then read and evaluated for its possible inclusion in this study. The focus of this study is to investigate structural SC, knowledge transfer, and innovation at different levels of analysis, namely at the intra-firm (inter-personal and inter-unit) and inter-firm levels. Therefore, the studies adopting a different level of analysis (e.g., national or regional studies), focusing only on the other SC dimensions (e.g., relational and cognitive dimensions of SC), or focusing on other outputs (e.g., business performance) were excluded.

Afterwards, a detailed content analysis of each paper was performed to confirm its relevance, resulting in a final sample of 109 articles. Articles examining the direct effect of structural SC on innovation (excluding KT) were also included in order to compare these findings with the findings obtained in the studies including also KT. This analysis was followed by a categorisation of the

studies according to the level of analysis and the sub-dimensions of structural SC (Nahapiet and Ghoshal, 1998). The following paragraphs review the literature on the relationship between these dimensions. At the end of each paragraph a short summary is provided to synthetise the findings emerging from the reviewed studies. The discussion section will discuss the strengths and weaknesses of previous works and provide directions for future research.

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Structural Social Capital and Knowledge Transfer

The structural dimension of SC reflects "the patterns of the social ties characterising a group of actors, it concerns the properties of the social system and the network of relations as a whole" (Nahapiet and Ghoshal, 1998, p. 244).

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Network Size

Intra-firm level – According to Burt (1992), being involved in large networks is beneficial for rapidly accessing to large quantities of unique information. Scholars have attempted to prove the presence of a relationship between network size and innovation. For instance, Rodan and Galunic (2004) found that the number of contacts within the managers' network of a telecom company has a marginally positive effect on their managerial innovations. Obstfeld (2005) and Moran (2005) found that the relationship between network size and involvement in product innovation and innovation performance respectively was not significant. Along a similar line, Maurer *et al.* (2011) found that the relationship between the number of ties and the transfer of either market or technological knowledge was not significant.

The disadvantages of being involved in large networks have been discussed by several authors.

McFadyen and Cannella (2004) found that increasing the number of ties requires increasing the amount of time, money and energy devoted to their management; hence, they show that increasing the network size over a certain limit can decrease the benefits associated with it. Hansen *et al.* (2005) revealed that the size of a team's network across subsidiaries increased the likelihood of knowledge seeking, while decreasing it within a team. Moreover, Fang, Lee, and Schilling (2012), showed that small and semi-isolated groups are better at preserving diverse ideas because they shelter heterodox ideas, enabling them to survive and be refined, rather than quickly extinguished through competition in the larger population.

The indirect effect of network size on innovation has been proved by Smith, Collins and Clark, (2005), who found that the number of contacts of top management teams and knowledge workers predicted the firms' capacity to access, absorb, combine and anticipate value from knowledge (knowledge creation capability), which mediated the relationship between network size and the number of new products and services developed.

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Inter-firm level – The research at the inter-firm level has also produced contrasting results regarding the relationship between SC and innovation. The first studies on strategic alliances in the chemical and biotechnology industries provided evidence for the innovation benefits associated with enlarging a network's size (Shan, Walker and Kogut, 1994; Powell *et al.*, 1996; Ahuja, 2000; Baum, Calabrese, and Silverman, 2000). However, these studies show that strategic alliances do matter for a firm's innovation performance without distinguishing which alliance and knowledge stock contributes more to such performance (e.g., Ahuja, 2000; Sampson, 2007) and without accounting for the additional resources (e.g., time, costs) needed to manage a large portfolio of business relations. Ahuja (2000) found that a large number of direct ties and a large number of indirect ties are positively associated with innovation outputs; though, having many indirect and direct ties is not

necessarily better because the organisations with many direct ties can be less able to profit from their indirect ties when compared to the organisations with fewer direct ties. The author also refers to the spillover of key information as a potential negative outcome of large networks. Similarly, Ahuja and Katila (2004) found that a large alliance portfolio hampers the firms' capability to integrate large unfamiliar streams of knowledge. Vanhaverbeke, Gilsing, and Duysters (2012) show that direct ties have an inverted U-shaped effect on the creation of both core and non-core technology; even hey are more beneficial for the creation of non-core technology, and beyond a certain limit the benefits of the number of ties start to decline and have a negative effect on the creation of core-technology.

Capaldo (2007) shows that by increasing network size and knowledge diversity, the focal firm can enjoy accessing, mobilising, and learning new knowledge. He reveals that when a focal firm is embedded into a small circle of strong ties, it creates isomorphism and blindness towards new opportunities, which over time decreases the growth rate of the lead firm's knowledge base, which impacts the firm's innovation capability negatively.

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Summary of findings - Scholars have attempted to prove the presence of a direct relationship between network size and innovation without considering the KT process and the type of knowledge shared. The majority of these studies have proved that the effect of network size on innovation is not direct. Thus, the predicting power of network size resulted to be weak or non-significant in the relationship with different innovation outputs especially in intra-firm level studies: innovation performance (Moran, 2005), involvement in innovation (Obstfeld, 2005), managerial innovation (Rodan and Galunic, 2004). However, some authors have recently accounted for the mediating power of knowledge types and knowledge processes in the relationship between network size and innovation and found that network size predicts innovation when it enables the access to

actors with diverse knowledge (Smith *et al.*, 2005; Capaldo, 2007).

Moreover, scholars have also discussed several disadvantages linked with increasing the breadth of interpersonal networks, such as the high costs needed to maintain such relationships (McFadyen and Cannella, 2004). At the inter-firm level, researchers have found that network size has an inverted U-shaped relationship with knowledge creation (Vanhaverbeke *et al.*, 2012), and it is also associated with negative outputs such as the spillover of key information (Ahuja, 2000), the inability to use indirect ties (Ahuja, 2000), and incapability to integrate unfamiliar knowledge (Ahuja and Katila, 2004). From this analysis, we can conclude that simply enlarging the number of contacts in a network does not necessarily lead to effective knowledge transfer, and subsequently to innovation.

Tie Strength

Intra-firm - Granovetter (1973) revealed that weak ties, which are characterised by low interaction frequency and relational distance, enable access to new information and facilitate individuals in their job searches. On the contrary, strong ties, which are characterised by high interaction frequency, a longer duration of the relationship, and relational proximity, enable access to redundant information.

Scholars have found that different types of ties foster the transfer of different types of knowledge. For instance, Hansen (1999) and other scholars (Reagans and McEvily, 2003; Uzzi and Lancaster, 2003) demonstrated that weak ties facilitate the search and transfer of public, useful, explicit knowledge, which, according to Hansen (1999), can be obtained with lower search costs than adopting strong ties, leaving more time and energy to be dedicated to completing a focal project. On the other hand, weak ties were found to provide access to non-redundant information (Levin and Cross, 2004) but they impede the transfer of complex or non-codified knowledge and such condition retards NPD projects (Hansen, 1999).

Research has provided evidence for the positives of strong ties by demonstrating that they facilitate the transfer of fine-grained information, private, high-quality, and tacit knowledge (Krackhardt, 1992; Hansen, 1999; 2002; Uzzi and Lancaster, 2003; Reagans and McEvily, 2003) and of technological and marketing knowledge (Maurer *et al.*, 2011). Strong ties are fundamental for transferring complex knowledge because they foster the development of relationship-specific heuristics, which increase the likelihood of tacit knowledge transfer (Uzzi, 1997). Accordingly, Hansen (2002) concluded that strong ties should be used for the transfer of tacit knowledge while weak ties for the transfer of explicit knowledge. Scholars have proved that the strength of ties predicts the knowledge creation capability and influence resource exchange and combination, which in turn predict innovation (Tsai and Ghoshal, 1998; Smith *et al.*, 2005).

Research has also investigated the other benefits that are associated with strong ties, such as higher mutual understanding and willingness to exchange information and knowledge and to cooperate for mutual benefit (Krackhardt, 1992; Tsai and Ghoshal, 1998; Reagans and McEvily, 2003; Gilsing and Nooteboom, 2005). Moreover, strong ties have been found to ease KT across units, and their effect is stronger when the source and the recipient work in different laboratories (network range) (Tortoriello, Reagans, and McEvily, 2012). The importance of strong ties for attenuating the negative influence associated with technological differences, geographic distance, and competition between individuals and business units when sharing knowledge has also been documented (Hansen and Løvås, 2004; Singh, 2005).

Researchers have also discussed the drawbacks associated with transferring and creating new knowledge with strong ties. Strong ties have been found to lead to conformity (Perry-Smith, 2005), and loss of objectivity (Locke, 1999). Reagans and McEvily (2003) note the presence of a tipping point for strengthening ties, over which the marginal returns to the additional time and effort put into a relationship begins to decline. McFadyen and Cannella (2004) conclude that although the strength of a tie is important for knowledge creation, longer relationships with the same exchange

partners can negatively impact knowledge creation because the exchange partners can develop knowledge stocks that are too similar, and they can become subject to group norms, obligations, and expectations. Hansen *et al.* (2005) found that the stronger the ties are among people in the same unit, the less likely that they will search for knowledge outside of their group, which is linked to the *not-invented-here syndrome* found in R&D settings by Katz and Allen (1982).

Recently, a new typology of tie has been introduced by Levin, Walter, and Murnighan (2011): the *dormant tie*, which is a former strong or weak tie that has grown out of touch. Dormant ties have been found to provide the same benefits usually associated with either strong ties or weak ties, such as, respectively, trust and shared perspective or access to novel knowledge and insights.

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Inter-firm – The positive influence of strong ties on some of the most important conditions (e.g., trust, shared understanding) enabling knowledge transfer has been emphasised also in inter-organisational studies (e.g., Uzzi, 1997; Dyer and Nobeoka, 2000; Capaldo, 2007; Williams, 2007; Mu, Peng, & Love, 2008). Accordingly, in Williams' study (2007), strong ties were found to increase the capability of the receiving firm to understand a source's knowledge in strategic alliances, which enhanced the adaptation of the knowledge received to the firms' operations. The mediating power of different knowledge transfer processes in the relationship between tie strength and different innovation outputs has been the focus of interest of several authors. For instance, Yli-Renko *et al.* (2001) found that strong ties allow firms to access a variety of technological knowledge, which mediates their relationship with knowledge exploitation. Capaldo (2007) in a study on industrial furnishing firms in Italy found that repeated social interactions enhance the development of mutual knowledge, social contents, and relation-specific investments, which reinforce each other in a double-loop relationship. These conditions favour the development of knowledge-intensive and trusted relationships, which can create a fertile environment for the cross-

fertilisation of network members and can lead to new knowledge creation. Wu (2008), in a study of family-owned manufacturing firms in Hong Kong, discovered that network ties and repeated interactions foster information sharing, which mediates the relationship between SC and competitiveness improvement. Tiwana (2008) revealed that strong ties complement bridging ties and that both significantly affect knowledge integration in project alliances, which mediate the relationship between SC and alliance ambidexterity (the ability to pursue exploration and exploitation simultaneously). In a recent study, Shu *et al.* (2012) have found that knowledge exchange influences knowledge combination (suggesting considering them as distinct knowledge creation processes) and that both mediate the relationship between business ties and product innovation.

The usefulness of the two types of ties for exploration and exploitation activities has been discussed by Rowley, Behrens, and Krackhardt (2000) and Atuahene-Gima and Murray (2007), the latter found that new innovations come from weak external networks and that these ties are best for exploration and creativity, while once these ideas are integrated into the recipient firm, intra-organisational knowledge transfer becomes vital for the exploitation and commercialisation of the innovation.

Furthermore, some scholars have addressed the dynamic and ever changing nature of the benefits achievable through the two types of ties (Gargiulo and Benassi, 1999; 2000; Adler and Kwon, 2002; Capaldo, 2007; Molina-Morales and Martínez-Fernández, 2009). For instance, Capaldo (2007) revealed that over time, a small network entirely characterised by strong ties produces homogeneity, reduces the number of contacts, decreases flexibility for collaboration with new partners, and diminishes responsiveness to new market opportunities. In sum, a small circle of strong ties jeopardises the firms' ability to respond to change, while weak ties speed up innovation by connecting a focal firm to otherwise difficult-to-reach knowledge areas. The author reveals that *dual network architecture*, based on a core of strong ties and on the capacity to integrate peripheral

heterogeneous weak ties (network diversity), enhances knowledge access, integration and potential exploitation, which all contribute to the firm's innovative capability. Finally, Molina-Morales and Martínez-Fernández, (2009) found that excessive social interactions and trust display an inverted U-shaped curve in their contribution to value creation.

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Summary of findings - Research has revealed that the relationship between tie strength and innovation, at both the inter- and intra-firm levels, is mediated by different knowledge types and KT processes. To this regard, Perry-Smith (2005) highlights the importance of considering not only the strength of the tie alone but also its heterogeneity in terms of the type of knowledge embedded in these ties. For instance, different KT processes such as knowledge access, integration, exchange, and combination have been found to mediate the relationship between tie strength and innovation outputs especially at the inter-firm level (e.g., Tiwana, 2008).

Strong ties have been found to favour the access to technological knowledge (Yli-Renko *et al.*, 2001), marketing knowledge (Maurer *et al.*, 2011), and to private, tacit and fine-grained knowledge (e.g., Hansen, 1999, 2002; Uzzi and Lancaster, 2003). Strong ties, at both the intra- and inter-firm levels, have been found also to positively affect the factors that create the conditions for the transfer of complex and tacit knowledge such as trust, cooperation, and the like (e.g., Gilsing and Noteboom, 2005), and they overcome also traditional KT barriers (e.g., geographical and technological distance) (Hansen and Løvås, 2004; Singh, 2005). Moreover, strong ties have been found to enhance different KT processes such as: knowledge integration (Williams, 2007; Tiwana, 2008), resource exchange (e.g., Tsai and Ghoshal, 1998), knowledge exchange and combination (Shu *et al.*, 2012), and knowledge creation (e.g., Smith *et al.*, 2005; Capaldo, 2007). The negatives of strong ties have been also discussed by researchers: loss of objectivity (Locke, 1999), group conformism (Perry-Smith, 2005), redundant knowledge (McFadyen and Cannella, 2004), lack of external search

for new ideas or knowledge (Hansen *et al.*, 2005). At inter-firm level, scholars have found that strong ties over time may lead to: incapability of sensing new opportunities, lower responsiveness, and a reluctance to access new knowledge due to over-embeddedness in a network (Gargiulo and Benassi, 1999; Capaldo, 2007).

On the one hand, weak ties have been found to speed up knowledge creation because they connect to new and difficult-to-reach knowledge areas and are more suitable for knowledge exploration activities (e.g., Hansen, 2002; Atuahene-Gima and Murray, 2007), are less expensive to maintain than strong ties, and they facilitate the transfer of public, explicit, and non-redundant knowledge (e.g., Reagans and McEvily, 2003). On the other hand, they impede the transfer of tacit and complex knowledge, which then impacts the NPD process negatively (Hansen, 1999).

Cohesive and sparse networks

Intra-firm – According to Burt (1992), structural holes positively influence creativity and innovation because they provide actors with timely access to diverse information. Rodan and Galunic's (2004) study showed a weak but positive relationship between managers with structural holes and managerial innovativeness, while Cummings (2004) found that work groups that present differences in terms of geographic locations, functional assignments, reporting managers, and business units (network range) improve access to diverse sources of knowledge, which is associated with improved performance.

The positives and negatives of the two structural network configurations were discussed by Obstfeld (2005), who found that dense social networks and bridging ties (*tertius iungens* orientation) predicted higher involvement in innovation activities; however, although sparse networks produce richer knowledge that is instilled with context, sparse networks are not able to implement this knowledge; Obstfeld labels this as the 'action problem' of bridging ties. Similarly,

Tortoriello and Krackhardt (2010), found that bridging both strong and weak ties across formal organisational boundaries is not significantly related to innovative performance, while bridging strong ties embedded in cliques is (Simmelian ties). In agreement with Obstfeld's argument, they concluded that access to heterogeneous ideas and knowledge is not enough to generate innovations because having new ideas is fundamentally different from implementing them.

Some scholars have integrated the sparse *vs.* cohesive network and the relational embeddedness (strong *vs.* weak ties) in the same model as they view them as complementary to one another (e.g., Reagans and McEvily, 2003). For instance, Reagans and McEvily (2003) found that both cohesive networks and network range ease KT; though, tacit knowledge is more likely to transfer across a structural hole when the individual that bridges the structural hole either has a strong tie across the hole or a diverse network. Similar results were obtained in Newell, Tansley, and Huang's (2004) study where the bridging-bonding aspects of SC were essential for knowledge integration: while the first provided access to knowledge, the latter favoured its integration.

McFadyen, Semadeni, and Cannella (2009) have provided evidence about the interdependency between tie strength and ego network density. They suggest that sparse networks provide diverse knowledge, while strong ties are efficient for capturing and utilising the knowledge made available through these sparse ego networks. Thus, these authors conclude that a sparse ego network composed of strong ties is the optimal configuration for knowledge creation. Along a similar line, Fleming, Mingo, and Chen (2007) revealed that network density coupled with contacts with diverse expertise increased the individuals' knowledge generation because they promote trust and reciprocity, facilitating the disclosure of diverse knowledge. Similarly, another study on global and local patent collaboration ties in the pharmaceutical industry support the same results: cohesive global networks hinder innovation performance (due to costs and lack of knowledge diversity), while a local cohesive network with bridging ties is positively related to innovation performance (Guler and Nerkar, 2012). The benefits of this configuration have been illustrated also by Hotho,

Becker-Ritterspach, and Saka-Helmhout (2011), where higher social interaction between headquarters and a subsidiary involving employees with diverse knowledge increased the firm's ability to integrate knowledge in the local context and to develop local applications. Finally, Tortoriello *et al.* (2012) investigated the effect of network cohesion and range in cross-laboratories KT. Their findings show that both cohesive network and range ease KT, but the effect of cohesive network is even more positive when KT occurs between R&D people from different organisational units and spanning different knowledge areas.

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Inter-firm – Hargadon and Sutton's (1997) study highlights the positive effects of structural holes in terms of new ideas and products generated by brokering among a variety of organisations and their products. Similar findings were obtained by McEvily and Zaheer (1999), where maintaining networks rich in bridging ties increased the likelihood of accessing new information, ideas, and opportunities.

In general, scholars warned about the negative effects of closed networks, which prevent their members from searching for new partners and which isolate them from the external world, resulting in a 'lock-in' situation or 'over-embeddedness' (Uzzi, 1997; Gargiulo and Benassi, 1999; 2000). Firms that are embedded within the local cohesive networks are more exposed to failure because their competencies follow a traditional technological trajectory that could be made obsolete by emergent worldwide competencies. This risk represents the *competency trap* described by Henderson and Clark (1990). In one of the rare studies including both intra and inter-firm levels, Edelman *et al.* (2004) found that bonding ties facilitate access to unavailable knowledge and enhance the development of trust, social cohesion and a shared identity at the group-level; however, bonding ties can constrain the exploration process, which can lead to the exclusion or rejection of new information and knowledge at the organisational level. The authors recommend

adopting both bridging and bonding configurations in order to foster innovation. Lazer and Friedman (2007) suggest that network density reduces the diversity of information available in a network over time, which reduces long-run innovation, while Schilling and Phelps (2007) found that the tie redundancy characterising closed networks improves innovation because the redundant ties ensure multiple pathways through which information can reach all network members quickly and reliably.

The contingencies of the effect of structural embeddedness in KT and innovation have been emphasised by many scholars (e.g., Ahuja, 2000; Maurer and Ebers, 2006). Accordingly, Ahuja (2000) proved that having many structural holes is associated with a reduced innovation output; he noted that the benefits associated with structural holes can be dependent on the context investigated. For instance, he states that 'when developing a collaborative milieu and overcoming opportunism are essential to success, closed networks are likely to be more beneficial. When speedy access to diverse information is essential, structural holes are likely to be advantageous' (ibid., p.451). Ahuja's (2000) assumptions were tested in Zaheer and Bell's (2005) study, in which the innovative focal firms' access to structural holes enhanced firm performance because the structural holes enabled fast access to new information that could be reflected in both new products and services, suggesting that a network composed of structural holes is more beneficial in contexts with a high speed of new product innovation. Similar results were obtained by Rowley *et al.* (2000), who found that closure is beneficial in the context of exploitation.

However, scholars have argued and also demonstrated that closure and structural holes are complementary rather than competing mechanisms and that they both contribute to KT (e.g., Burt, 2000; Reagans and McEvily, 2003; Phelps, 2010; Baum, McEvily, and Rowley, 2012). Accordingly, Baum *et al.* (2012) state that the combination of closure and bridging enhances firm performance as they provide ready access to diverse information sources (through bridging) and facilitate efficient exchange and integration of information (through closure). Schilling and Phelps

(2007) discuss the value of both clustering and some amount of random linking for knowledge creation and conclude, in accordance with previous studies (Uzzi and Spiro, 2005), that cohesion and connectivity foster the transmission of creative material that can be recombined into new creative products. Phelps (2010) reveal that a closed network composed of partners with a higher technological diversity is beneficial to knowledge exploration; in fact closure increases KT, which affects the firms' ability to benefit from technologically diverse partners.

The importance of the two network configurations at different points in time and for different innovation stages has been investigated in qualitative case studies (e.g., Harryson *et al.*, 2008). In an attempt to investigate the movement from one type of network configuration to another, depending on the firms' learning scopes and NPD stages, Harryson *et al.* (2008) studied the development of the new Volvo C70, highlighting the need for the focal company to pass from an 'open' network configuration during the exploration phase to a more 'closed' configuration in the exploitation phase. Along a similar line, Gilsing and Nooteboom (2005) illustrate the dynamics of moving between sparse and dense networks: firms operating within the biotechnology sector move from sparse to dense networks during the cycle of discovery, where firms go from the exploration to the exploitation phase and vice versa. Dittrich and Duysters (2007) analysed the formation of SC in Nokia's NPD process. For earlier generations of mobile telephony, Nokia's product development was maintained as an internal activity. However, recently, to develop third generation telephony, the Finnish company has kept a balance of both an exploitation network formed of dense ties and an exploration network that adopts a more organic and flexible way of working. The findings show that the balance of closure and openness in the innovation process has enabled Nokia to adapt to the market and to exploit new opportunities.

Some scholars have integrated structural embeddedness and relational embeddedness in the same model and found that strong ties complement bridging ties in enhancing knowledge integration, which mediates the influence of SC on firms' ambidexterity (Tiwana, 2008). Bae and Koo (2008)

analysed the joint effects of four different kinds of relationships on KT: a sparse network with weak ties, a sparse network with strong ties, a dense network with weak ties and a dense network with strong ties. Their results show that a sparse network coupled with strong ties appears to be the optimal configuration for enhancing KT.

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Summary of findings - Research has stressed the importance of different knowledge types and transfer processes as important factors which cannot be simply implied when measuring the influence of different network configurations on KT processes and innovation. Scholars have emphasised the importance of not equating a network of disconnected contacts to a network that is also heterogeneous in knowledge. Moreover, the role played by heterogeneous knowledge on managerial innovation alone is noteworthy and higher than the influence played by structural holes (Rodan and Galunic, 2004). In accordance with these authors, Phelps (2010, p. 906) states: "prior conflicting findings about the effect of structural holes on firm innovation may be influenced by a confounding of the structural holes effect with an unobserved compositional effect of partner knowledge diversity". Thus, it follows that the degree of diversity of knowledge embedded in structural holes is an important factor to take into account.

Moreover, scholars did not only stress the importance of the network content (e.g., knowledge characteristics), but also the critical role of KT process in the relationship between SC and innovation. From the reviewed literature it emerges that each configuration can be beneficial to enhance different transfer processes, which are critical at the different stages of the innovation process. One the one hand, structural holes are important to access to knowledge that is non-redundant, rich and diverse (e.g., Hargadon and Sutton, 1997; McEvily and Zaheer, 1999; Lazer and Friedman, 2007); however, to integrate and combine knowledge, a more cohesive network is

needed (Obstfeld, 2005). Accordingly, some scholars have argued that these apparently opposite network configurations are, in reality, complementary to one another. For instance, the optimal network configuration combines elements of cohesion and sparseness, proximity and diversity, strong and weak ties (Ahuja, 2000; Reagans and McEvily, 2003; Obstfeld, 2005). In accordance with this view, we have witnessed a surge of researches that include cohesive and sparse networks, and structural and relational embeddedness in the same model by providing a clearer indication about the optimal SC configuration for enabling different KT processes (e.g., Tiwana, 2008).

Centrality

Intra-firm – At inter-unit level, Tsai and Ghoshal (1998) found that centrality had an indirect effect on resource combination and innovation, whose effect was mediated by trust. In another study, a business unit's central position and high absorptive capacity created a positive impact on performance and innovativeness (Tsai, 2001). A business unit's central position increases the extent to which other units in an organisation consider it to be an important source of knowledge, thereby increasing their motivation to learn from it (Andersson, Forsgren, and Holm, 2002). Mehra *et al.* (2006) found that high centrality provides the ego with easy and speedy access to a large number of contacts with critical opportunities and resources because shorter paths to direct and indirect actors are available to a centrally positioned ego. Their finding are similar to other studies who have shown that centrally located actors have more contacts, which eases the access and acquisition of external knowledge (Hansen, 2002; Monteiro, Arvidsson, and Birkinshaw, 2008). Moreover, Monteiro *et al.* (2008) revealed that the peripheral business units in a multinational are rarely engaged in knowledge sharing and experience a "liability of internal isolation" and they are less performing than subsidiaries that are not isolated because knowledge tend to flow from and to business units that more frequently share knowledge (reciprocity argument). In contrast, Fang *et al.*

(2012), in accordance with previous scholars (O'Reilly and Tushman, 2004), found that peripheral and semi-isolated groups nurture the development of new ideas in NPD teams. Finally, individuals who span structural holes and have high centrality signal the richness and quality of their knowledge to their peers who will then be more likely to choose such knowledge (Nerkar and Paruchuri, 2005).

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Inter-firm – Research on centrality at the inter-firm level is scarce and mostly focused on the interaction between geographic location and network position in predicting knowledge creation. Centrality in a network of geographically dispersed businesses was found to increase knowledge creation in the Boston biotechnology community (Owen-Smith and Powell, 2004). In another similar study, Whittington, Owen-Smith, and Powell (2009) have shown the positive impact of global centrality and propinquity to public research organisations on patenting activity.

In a longitudinal multilevel study on eight pharmaceutical companies, Paruchuri (2010) discovered that the centrality of a firm's inventors produces an inverted-U-shaped relationship with the firms' innovation. The central actors benefit from the amount and the speed of information flow, which typically leads to the improved quality of their knowledge. However, when this information flow increases beyond a certain amount, the inventors can no longer process all of the information properly, decreasing the promotion of their knowledge to others and thereby diminishing their innovation efficiency. The authors also found that as a firm's structural centrality in an inter-firm network increases, the threshold value of centrality at which the impact of the inventors becomes negative decreases; as a firm's span of structural holes in the inter-firm network increases, the threshold value of the inventor centrality at which the impact turns negative increases.

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Summary of findings – Central actors benefit from being perceived as reliable, trustworthy and authoritative sources of knowledge by virtue of the position that they hold in the network, improving their reputation and, in turn, affecting *the alter*'s willingness to share knowledge with them. Therefore, central actors have an easy and speedy access to the knowledge that they look for in an inter-personal or inter-unit network, which will affect the likelihood of knowledge creation. However, intra-firm studies have also emphasised that the effect of centrality is moderated by the number of ties (in the relationship with creativity) (Perry-Smith, 2005), is mediated by trust (in the relationship with innovation) (Tsai and Ghoshal, 1998), and central people need to span structural holes to have their knowledge adopted (Nerkar and Paruchuri, 2005). Moreover, in some situations (NPD projects), peripheral and semi-isolated work groups are more beneficial for developing new ideas (Fang *et al.*, 2012).

At the inter-firm level, centrality appears to be more beneficial when a company is considered to be central in a geographically dispersed network, such as a global network, or in proximity to public research organisations (e.g., Owen-Smith and Powell, 2004; Whittington *et al.*, 2009), which potentially increases the capability of the central actor to reach diverse actors and benefit from specialised and heterogeneous knowledge. However, scholars have also emphasised that the benefits of centrality might not last forever, and that the larger the size of central firms connected to the other central companies in their network, the lower will be the innovation efficiency (Paruchuri, 2010).

Discussion and future research directions

This study has reviewed the literature on structural SC, KT, and innovation at the inter- and intra-organisational levels (inter-personal and inter-unit) that has been published in strategy, management, and organisational behaviour journals in the last 20 years. The majority of studies on

structural SC focus on the relational and structural embeddedness, namely they investigate the role of strong and weak ties, and of cohesive network and structural holes in KT and innovation.

This study has shown that a number of researchers have measured the relationship between SC and innovation often simply implying the resources (knowledge types) acquired through social relationships and the (KT) processes that enable SC to transform the resource in order to generate innovations. In these studies, SC is often viewed as a black box that produces innovation. Accordingly, the mediating processes and capabilities that enable individuals and businesses to transform tacit and explicit knowledge into innovation are often not accounted for. As a result, most of these studies have produced inconsistent or contradicting results on the role of structural SC on innovation at the different levels of analysis (e.g., Ahuja, 2000; McFadyen and Cannella, 2004; Rodan and Galunic, 2004; Obstfeld, 2005; Moran, 2005; Molina-Morales and Martínez-Fernández, 2009; Tortoriello and Krackhardt, 2010; Maurer *et al.*, 2011). Therefore, one of the reasons of these contrasting results can be explained by the importance of different knowledge types and KT processes in such relationship. For instance, Rodan and Galunic (2004) emphasised that it is important that a network of disconnected contacts (structural holes) is not equated to a network that is also heterogeneous in knowledge. In fact, they show that access to heterogeneous knowledge is more important for innovation than access to structural holes. Along a similar line, Tortoriello and Krackhardt (2010) found that access to structural holes is not enough to generate innovations, while Maurer *et al.* (2011) revealed that there is no direct relationship between SC, performance, and innovation outcomes. Throughout this review, we have also synthesised the studies of scholars who have considered different knowledge types and KT processes as mediating factors in the relationship between structural SC and innovation. These scholars have provided empirical evidence for the argument that KT processes and different knowledge types mediate in a significant way the relationship between structural SC and innovation outcomes in either intra-firm or inter-firm contexts (e.g., Yli-Renko *et al.*, 2001; Smith *et al.*, 2005; Tiwana, 2008; Wu, 2008; Mu *et al.*,

2008; Maurer *et al.*, 2011; Shu *et al.*, 2012; Martínez-Cañas *et al.*, 2012). Therefore, this study clarifies the indirect effect of SC on innovation and emphasises the importance of measuring and not simply implying the different KT processes and the different knowledge types when assessing the role of SC in innovation. Indeed, it is evident that different SC dimensions interact with different knowledge types and based on the type of knowledge that is shared and the effectiveness of the different KT processes, SC can be productive of innovations from the combined knowledge. Therefore, scholars should distinguish the social and human capital aspects in their theoretical models in order to get the most relevant results when investigating the relationship between SC and innovation. Accordingly, social and business relations are important, but valuable knowledge must be effectively shared and combined through these relations in order to generate innovations. Thus, SC enhances innovation at intra- and inter-organisational level through an effective transfer of knowledge that is also perceived as valuable and useful for generating innovations by the exchange partners.

In this paper, we have acknowledged that the majority of studies on structural SC focus on its impact on knowledge transfer, knowledge access (or acquisition), knowledge creation (or generation), knowledge exploration, and knowledge exploitation. These studies have found that SC is a critical antecedent of these KT processes. However, some KT processes have received less attention, such as knowledge assimilation at the intra-firm level or knowledge integration between firms (Williams, 2007; Tiwana, 2008; Hotho *et al.*, 2011), and knowledge search at both levels (e.g., Hansen *et al.*, 2005). Therefore, more attention should be given in the future to how structural SC dimensions affect these KT processes at both the intra- and inter-firm level.

Although scholars have found that different SC configurations are effective for different KT processes, the current literature review highlights that it is very difficult to compare studies in the area of SC and KT. This difficulty is also due to the fact that scholars sometimes use different terms or measured KT in idiosyncratic ways. For instance, to measure knowledge creation and flows some

scholars use patents count (Owen-Smith & Powell, 2004; Schilling and Phelps, 2007), others use the number of scientific publications (McFadyen and Cannella, 2004; McFadyen *et al.*, 2009), others adopt patents' citation (Singh, 2005), while Smith *et al.* (2005) measure knowledge creation as the individuals' access, absorption, combination, and anticipation of value from knowledge, labelled as absorptive capacity elsewhere (Cohen and Levinthal, 1990). However, Shan *et al.* (1994) and Ahuja (2000) use patent application to measure innovation and not knowledge creation.

Moreover, some studies refer to KT though they incorporate different processes to measure KT (e.g., Smith *et al.*, 2005; Uzzi and Lancaster, 2003; Maurer *et al.*, 2011); others measure the performance of KT activities in terms of ease or frequency of KT (e.g., Tortoriello *et al.*, 2012); while other authors refer to the degree of codification of the knowledge being shared (Hansen, 1999, 2002). Additionally, this literature review has documented that only few studies have investigated the causal relationships between different KT processes (Yli-Renko *et al.*, 2001; Williams, 2007; Shu *et al.* 2012). For example, Williams (2007) found that knowledge adaptation and replication vary separately, are used jointly, and both affect KT, while Shu *et al.* (2012) view knowledge exchange as an antecedent of knowledge combination. Therefore, future research should describe how the search, acquisition, assimilation, and exploitation of knowledge resources unfold.

Moreover, research on structural SC has rarely considered the individual or business' capability to 'recognize the value of new, external knowledge, assimilate it, and apply it to commercial ends', namely absorptive capacity (Cohen and Levinthal, 1990, p.128). Although absorptive capacity has been indicated to be an important determinant of inter-firm knowledge sharing (Lane and Lubatkin, 1998; Tsai, 2001); yet, this construct has been neglected in studies on SC, KT, and innovation. Thus, we recommend future research to measure the influence of absorptive capacity in such relationship. Furthermore, additional effort should be done in order to consider the relationships between KT processes at both the intra and inter-firm levels in order to shed light on the role of structural SC at the different levels of analysis (Brass *et al.*, 2004). For instance, scholars could investigate how

structural SC influences the way a company acquires knowledge resources at inter-firm level and then integrates the same knowledge at intra-firm level.

Different knowledge, different benefits

In this study, we have acknowledged that existing research in SC often does not always distinguish between the distinct knowledge types (e.g., Hansen, 1999, 2002; Reagans and McEvily, 2003). However, different knowledge types provide different benefits (Haas and Hansen, 2007); for instance tacit knowledge has a higher strategic value than explicit knowledge because it is more likely to lead to breakthrough innovation (Nonaka, 1994; Pérez-Luño *et al.*, 2011). Distinct types of knowledge require different strategies to be transferred, namely a codification for transferring explicit knowledge or a personalisation strategy for transferring tacit knowledge (Hansen *et al.*, 1999). However, future research could investigate the influence that advanced KT technologies currently used in the NPD process (e.g., knowledge management systems, virtual collaboration platforms, digital mock-up) can exert on the capability of weak ties to transfer complex and tacit knowledge.

Moreover, several studies have found that strong ties are conducive to tacit and complex KT, while explicit knowledge might only need weak ties to be shared (e.g., Krackhardt, 1992; Uzzi, 1997; Hansen, 1999; Reagans and McEvily, 2003). Future research could investigate if SC fosters the transfer of different types of knowledge than the ones already researched (e.g., tacit *vs.* explicit, public *vs.* private). For instance, scholars have ignored other knowledge dichotomies such as independent *vs.* systemic, and simple *vs.* complex knowledge (Garud and Nayyar, 1994). Future research could investigate how structural SC contributes to their transfer and see how and if the different knowledge types lead to different innovation outputs.

Furthermore, scholars should also consider other characteristics or properties of the knowledge being shared. For example, researchers could adopt the resource-based view (RBV) to measure the

attributes of the knowledge being shared in terms of its value, rarity, imperfect imitability and non-substitutability (VRIS) (Barney, 1986). Thus, research could investigate if SC predicts the transfer of this type of knowledge and if the latter fosters a firm's innovation and sustained competitive advantage. The RBV theorists argue that the more of these characteristics (VRIS) that are present in the resource of a firm (e.g., knowledge), the higher its contribution to the firms' competitive advantage will be (Barney, 1986). Although sharing VRIS knowledge could be critical for achieving radical innovations and fostering a collaborative advantage, companies are very careful about disclosing it because they could lose their knowledge advantage over their competitors (Inkpen and Beamish, 1997). For instance, research has shown that in inter-firm contexts, partners can become strong competitors by virtue of their newly developed competencies from the alliance (Inkpen and Beamish, 1997). Thus, we can infer that to share VRIS knowledge, a very high level of SC and a long-term horizon should permeate the relationships of the firm. In inter-firm contexts, when companies start to collaborate, they often limit the sharing to 'first-level knowledge', which can be tacit, however, it has often a low value, meaning that it can be common, generic, comparable, and easy to imitate. This is due to the fact that at the beginning of business collaborations companies limit the sharing of their valuable resources as trust and norms might not be as high and well-established because they need frequent social interactions to develop. As a consequence, the network members are very protective of VRIS-type knowledge when partnering with other businesses, whose reliability can be established only after time and repeated social interactions. To improve relationships, businesses and individuals need repeated social interactions because the more frequent and intensive these social interactions are, the greater the intensity, frequency, and breadth of the information exchanged (Yli-Renko *et al.*, 2001). The reinforcement and strengthening of ties and the formation of a closer relationship can be nurtured by mutually beneficial exchanges and relation-specific investments. All of these can contribute to the development of tacit and formal shared norms of behaviour, to further mutual commitment, to

increased levels of interactions and trust, which can contribute to increase the willingness to share knowledge that is more valuable. In such context, the exchange partners feel that they can obtain huge benefits without requiring too much protection for restraining potential opportunistic behaviours, which contributes to a more effective transfer of valuable knowledge. Furthermore, it is only after network members begin to work together on explicit and tacit but non-VRIS knowledge and grow to know each other that the conditions might become good for moving the partnership to the next stage, in which the VRIS-type knowledge can be shared and eventually combined. Therefore, we argue that a high level of SC might contribute to explaining a partner's decision to share and exploit VRIS knowledge, which can ultimately lead to breakthrough innovation. Thus, future research in SC adopting a longitudinal approach could consider VRIS knowledge transfer as a potential output of SC and as a mediating factor between SC and competitive advantage or innovation performance.

Network size

Previous studies on network size and innovation in strategic alliances (e.g., Powell *et al.*, 1996) mostly failed to consider the differences of knowledge stocks of the business partners which have been found to be important for determining the success of partnerships in more recent studies (e.g., Sampson, 2007). It is indeed important to account for the differences of the partners in terms of the knowledge that they hold, namely network heterogeneity, and that they make available for combination purposes in a business relationship. In fact, firms benefit from organizing alliances when technological diversity between them is higher (e.g., Sampson, 2007). In general, it has been found that it is the proportion of strong and weak ties and the diversity of the knowledge embedded in these ties that matters for the generation of new knowledge and not the mere size of the network (Capaldo, 2007). It follows that it is beneficial to have some strong ties as well as a high number of weak ties with diverse knowledge, but also to develop the capability to absorb, integrate, and

exploit the knowledge embedded in these networks. Therefore, future research on network size at both levels should evaluate the interaction of network size with tie strength, knowledge diversity, and absorptive capability for predicting KT and innovation.

Tie strength

From research on tie strength it emerges that individuals, groups and companies that fail over time to source new partners with different competencies can become trapped into their own small network of strong ties (Gargiulo and Benassi, 2000; Capaldo, 2007). Thus, to exploit the benefits and avoid the drawbacks of the two typologies of ties, a dynamic attitude toward tie management and the balance of the proportion of strong and weak ties (*dual network structure*) over time, and according to the different needs of ego, it is the optimal approach. Accordingly, this study acknowledges that scholars increasingly agree on the best degree of relational embeddedness at the different levels, which support the complementarity of both types of ties: a network composed of strong ties and coupled with some weak ties with heterogeneous knowledge is the optimal network configuration for accessing, integrating, and creating knowledge and subsequently achieving higher innovation performance. For instance, the integration of both ties could be beneficial at different stages of the innovation process, in which different KT activities are undertaken, and different types of knowledge are needed. For example, in the NPD process, firms pass from the 'fuzzy-front end' (idea generation and screening), where several ideas are collected and evaluated, to the development stage, where only a limited number of these ideas are adopted to develop a new product offering (Cooper, 2001). Thus, while at the fuzzy front-end, a large network of weak ties can be beneficial for searching and accessing a large amount of new ideas and knowledge, at the product prototype development stage the network configuration could evolve toward a more cohesive network of strong ties in order to be capable of integrating knowledge and to allow the achievement of the level of mutual understanding that is necessary to combine knowledge and

develop new product offerings.

Moreover, research has found that the maintenance of strong ties is more expensive than weak ties because it requires more time and energy (Reagans and McEvily, 2003); however modern communication technologies and social networking platforms are increasingly allowing people and businesses to connect, collaborate and work together without the necessity of having intimate relationships and frequent face-to-face interactions (Füller and Matzler, 2007; Huston and Sakkab, 2006). Computer-mediated communications have been found to be able to build strong and intimate relationships (Walther, 1996) with low investments in terms of physical interactions, time and energy. Researchers could investigate whether advanced KT technologies and social media platforms enable the ego to lower the costs needed to maintain multiple strong and weak ties.

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Cohesive vs. sparse networks

The review of the literature on cohesive and sparse networks has provided several insights about the optimal network configuration of SC that firms should adopt to enhance KT processes and consequently innovation performance. In this regard, the configuration that seems to be the best to enhance knowledge access, integration, exploration and exploitation at both the intra- and inter-firm level is a network structure with strong ties that dynamically span structural holes with heterogeneous knowledge (e.g., Reagans and McEvily, 2003; Fleming *et al.*, 2007; Phelps, 2010; Baum *et al.*, 2012; Guler and Nerkar, 2012). In accordance with the complementary argument among different network configurations, these studies show that structural holes, which need to be diverse in terms of the knowledge they own, are beneficial for a ready access to knowledge or for exploring new ideas (e.g., Phelps, 2010), but a cohesive network structure is needed to implement them (e.g., Gilsing and Noteboom, 2005) as closure facilitates efficient exchange and integration of knowledge (Baum, McEvily, and Rowley, 2012).

From the analysis of longitudinal studies it is possible to identify other important managerial aspects that might affect KT processes for the generation of innovation, namely flexibility and dynamicity in the management of networks. Flexibility and dynamicity both enable an actor to not being locked-in in a network of closed and homogeneous relationships that are not anymore beneficial after a certain period of time to achieve the changing needs of a focal actor. Then, a flexible, dynamic, and balanced approach in the management of networks is likely to be the most beneficial for a focal actor, who will move across structural holes and cohesive networks and adjust its network according to changing knowledge needs and business challenges. This approach is in accordance with a contingent and dynamic view of the benefits of SC. In fact, the optimal configuration of a network would be the one that enables an actor to dynamically switch to different SC configurations and ties according to his knowledge needs, which may be different in different conditions such as the stage of a firm's development stage (Maurer and Ebers, 2006), and NPD stage (Harryson, 2008), and others. A balanced and dynamic approach is fruitful to simultaneously explore and access disconnected actors and heterogeneous sources of knowledge by bridging structural holes, and to maintain the ties with those actors with whom the firm has an established record of collaboration. Successful firms retain the quality of their established ties in the business community and, at the same time, bridge structural holes that can be efficiently used to explore new knowledge areas. The proposed approach may be fruitful to overcome the barriers to KT and, simultaneously, benefits the 'bright' sides of the two network configurations. Future research should adopt longitudinal comparative case study in order to examine how innovative companies overcome KT barriers through SC, and how they adjust their network configuration over time in relation to the changing knowledge needs.

Centrality

The present review acknowledges that a central position is either beneficial or detrimental for easily

and rapidly accessing the necessary knowledge for knowledge creation. This literature review reveals that there is a dearth of studies on centrality at the inter-firm level and on how centrality contributes to knowledge search, acquisition, integration, and on how the latter KT processes affect innovation. Moreover, except for Nerkar and Paruchuiri's (2005) study at intra-firm level, we found that existing studies have not yet included both *centrality* and *structural embeddedness* in the same research model to explain KT and innovation. A central actor position in a network might affect its capability to also play the role of knowledge broker, benefiting of its power and position in order to access to a wider range of knowledge from different companies and organisations.

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Table 1. Knowledge transfer definitions

Author	***Knowledge transfer definition***
Grant (1996)	Knowledge acquisition and integration.
Szulanski (1996)	Initiation, implementation, ramp-up, and integration (transfer of best practices).
Yli-Renko, Autio, and Sapienza (2001)	Knowledge acquisition and exploitation.
Hansen (1999), Hansen, Mors, and Løvås (2005)	Knowledge search.
Maurer et al., (2011)	Mobilisation (search), assimilation, and utilization of knowledge resources.

Table 2. Knowledge transfer processes and definition

Knowledge transfer process	***Definition***
Knowledge search	Entails the activity of the individual/group/focal firm in looking for and identifying useful knowledge that is produced externally.
Knowledge access (or *acquisition*)	The activity of accessing to externally generated knowledge that is critical to an individual/group/focal firm's operations.
knowledge assimilation (or *absorption*)	The process of analysing, processing,

	interpreting, and understanding the knowledge obtained from external sources.
knowledge integration (or *combination*)	The activity of combining of new external knowledge with existing internal one.

Table 3. Journals with higher number of articles reviewed

Journal Title	***Number of Articles***
Strategic Management Journal	24
Academy of Management Journal	13
Organization Science	12
Administrative Science Quarterly	11
Academy of Management Review	7
Management Science	6
American Journal of Sociology	4
Journal of Product Innovation Management	3
Journal of Management Studies	3
British Journal of Management	3
Journal of Knowledge Management	3

Table 4. Dimensions of structural SC

Dimension	***Constructs***
Number of ties	Large *vs.* small network size
Nature of Ties	Strong *vs.* weak ties
Position in the network	Central *vs.* peripheral
Configuration of the network	Cohesive networks *vs.* structural holes

Table 5 - Structural dimension - Network Size - Intra-firm

Table 5

Author	***Method and Sample***	***Nature of Relationship***	***Dependent variable***
Rodan and Galunic, 2004	Survey of 106 middle managers' network in a European telecommunications company	Positive but marginal	Managerial innovation (individual creativity and implementation effectiveness).
McFadyen and Cannella, 2004	Panel data methodology of research scientists involved in university-related biomedical research	Inverted U shaped relationship. Tipping point over which benefits decrease	Knowledge creation (scientific publications)
Obstfeld, 2005	Survey of 182 employees from an engineering division of a major Detroit automotive manufacturer and 12 month ethnography	Non - significant	Degree of involvement in product innovation
Hansen, Mors, and Løvås, 2005	Data set of 121 new product development teams and 27 subsidiaries of a large high-technology company	Positive - Network size	Higher probability of inter-subsidiary knowledge seeking attempts
Moran, 2005	Survey of 120 sales and marketing managers of a Fortune 100 company in the pharmaceutical industry	Non-significant	Task Innovation (human resource managers ratings of managers' innovation performance)
Fang, Lee, and Schilling, 2010	Agent-based computer simulation model	Negative	Small groups are better in preserving the development of new ideas
Maurer Bartsch and Ebers, 2011	Analysis of data from 218 projects in 144 firms in the German machine engineering industry	Non-significant	Transfer of (mobilisation, assimilation, and utilisation) market knowledge (market trends and opportunities, competitors, and customers); and technological knowledge (new ideas, products and technologies).

Table 6 - Structural dimension - Network Size - Inter-firm

Table 6

Author	***Method and Sample***	***Nature of Relationship***	***Dependent variable***
Shan, Walker and Kogut, 1994	Analysis of databases on 85 start-ups that had cooperative agreements	Positive	Innovativeness (number of patents)
Ahuja, 2000	Longitudinal study of firms in the international chemicals industry based on databases on collaborative and patenting activity	Positive - large number of direct ties Positive - large number of indirect ties Negative - large number of direct and indirect ties	Innovation output (patenting frequency) Innovation output (patenting frequency) A large number of direct ties makes difficult to exploit the benefits of indirect ties
Capaldo, 2007	Longitudinal multiple case study on three design-intensive Italian furnishing firms	Negative - small circle of strong ties Positive - strong ties integrated with large periphery of weak ties	Knowledge base development Access, integration, exploitation of new knowledge, which mediate firms' innovation capability
Schilling and Phelps, 2007	Longitudinal study of the patent performance of 1,106 firms in 11 industry-level alliance networks	Positive – Reach	Increases the quantity and diversity of knowledge available to firms in the network
Vanhaverbeke, Gilsing, Duysters 2012	Empirical study on 116 firms in the pharmaceuticals, chemicals, and automotive industries with patent data from the US office	inverted U-shaped - Direct ties	Creation of both core and non-core technology (patents citation)

Table 7 - Structural dimension - Tie strength - Intra-firm

Table 7

Author	***Method and Sample***	***Nature of Relationship and Typology of Tie***	***Dependent variable***
Krackhardt, 1992	Social network analysis of 26 employees of a small entrepreneurial firm	Positive - strong ties	Transfer of information
Tsai and Ghoshal, 1998	Survey of 15 Business units multinational (MNE) electronics company	Positive - Strong ties	Resource combination and exchange (information, product, personnel, and support)
Hansen, 1999	Interviews with managers and survey of 120 NPD projects undertaken by 41 divisions of a large electronics company	Positive - weak ties Negative - weak ties	Search of useful knowledge Transfer of complex, tacit knowledge
Hansen, 2002	120 NPD projects in 41 business units of a large multiunit electronics company	Positive - strong ties Positive - weak ties	Transfer of tacit knowledge Transfer of explicit knowledge
Uzzi and Lancaster, 2003	Interviews and ethnographic observations at 11 US banks	Positive - arm's-length ties Positive - embedded ties	Transfer of public knowledge (learning, searching, utilizing) Private knowledge transfer
Reagans and McEvily, 2003	Survey of 103 employees of a contract R&D firm located in US	Positive - strong ties Potentially negative - strong ties	Ease the transfer of tacit knowledge Non-linear effect, presence of a tipping point at which marginal returns to additional time and effort begin to decline
Levin and Cross, 2004	Survey of 127 respondents from an American pharmaceutical company, a British bank, and a Canadian oil and gas company	Positive - strong ties through benevolence-based and competence based trust Positive - weak ties	Access to useful knowledge Access to non-redundant information Ease the transfer of codified knowledge

Hansen & Løvås, 2004	Survey of 121 project managers from a large high-technology MNE	Positive - strong ties	Knowledge (competence) transfer
McFadyen and Cannella, 2004	Survey of 173 research scientists involved in university-related biomedical research	Inverted U-shaped relationship - strong ties	Knowledge creation – tipping point over which benefits of strong ties decrease
Perry-Smith, 2005	Survey of 109 respondents among researchers in two laboratories of an applied research institute	Positive - weak ties coupled with heterogeneous set of direct contacts Negative - strong ties	Creativity (supervisors rated the creativity of their group members' work over the past two years using a five-item scale)
Singh, 2005	Empirical analysis of patent and collaboration dataset	Positive - strong ties	Knowledge flows (patent citation data) increase independently of geographical distance
Hansen, Mors and Løvås, 2005	Data set of 121 new product development teams and 27 subsidiaries of a large high-technology company	Negative - strong ties Positive - weak ties	Fewer inter-subsidiary knowledge seeking attempts Knowledge search costs are higher with strong ties and lower with weak ties
Moran, 2005	Survey of 120 sales and marketing managers of a Fortune 100 company in the pharmaceutical industry	Positive - strong ties	Task innovation
Smith, Collins and Clark, 2005	Survey of top management teams and knowledge workers from 72 technology firms	Positive	Knowledge creation capability (*access* to people or groups with specialized information; ability to *absorb and combine* information that has been exchanged; *anticipate value* from the exchange and combination process)
McFadyen, Semadeni and Cannella, 2009	Large sample of scientific publications and co-authors over an 11-year period	Positive - average tie strength x density Positive - strong ties x bridging ties	Knowledge creation (scientist publication record in a given year)
Maurer Bartsch and Ebers, 2011	Empirical study of 218 projects in 144 firms in the German machine engineering industry	Positive - strong ties	Transfer (mobilisation, assimilation, and utilization) of market and technological knowledge

Levin, Walter and Murnighan, 2011	Survey of 129 Executive MBA students	Positive - dormant strong and weak ties	Receipt of useful and novel knowledge
Tortoriello, Reagans and McEvily, 2012	Multiple methods. Interviews with R&D managers and researchers and survey with 247 individuals across R&D divisions of a large multinational high-tech company	Positive - strong ties	Ease of knowledge transfer across organisational unit

Table 8 - Structural dimension - Tie strength - Inter-firm

Table 8

Author	***Method and Sample***	***Nature of Relationship and Typology of Tie***	***Dependent variable***
Uzzi, 1997	Ethnography of 23 entrepreneurial firms in New York	Positive and negative - strong ties	Enable the transfer of tacit, fine-grained and holistic information but over time inhibit the access to information and knowledge diversity
Gargiulo and Benassi, 1999	Longitudinal study on start-up development	Positive - strong ties Negative - strong ties	Enables resource acquisition Over time inhibits the start-up from sensing emerging opportunities
Yli-Renko, Autio and Sapienza, 2001	Survey of 180 entrepreneurial high-technology ventures based in the UK	Positive - strong ties	External technical know-how acquisition (from customers), which mediates the relationship with technological distinctiveness and knowledge exploitation
Smith, Collins, and Clark, 2005	Survey of top management teams and knowledge workers from 72 technology firms	Positive - strong ties	Knowledge creation capability, which mediates the relationship with innovation
Capaldo, 2007	Longitudinal multiple case study on design-intensive Italian furnishing firms	Positive - strong ties	Deepening of mutual knowledge, develop trust, social contents and relation specific investments which creates a fertile

		Negative - Strong ties Positive - dual network architecture based on strong ties integrated with a large periphery of weak ties	environment for knowledge creation and innovation Homogeneity, and reduce the number of contacts, decrease flexibility for collaboration with new partners, and diminish responsiveness to new market opportunities Knowledge access, integration and exploitation
Mu, Peng, and Love, 2008	Qualitative study in a science and technology park in China	Positive - interaction frequency	Knowledge acquisition, which mediate the relationship between strong ties and innovation
Wu, 2008	Survey of 108 Hong Kong-based Chinese family businesses from the manufacturing sector	Positive - strong ties	(business/market) Information sharing, which mediates the relationship between SC and competitive advantage
Tiwana, 2008	Survey of 142 individual and 42 innovation-seeking project alliances involving a major American e-business conglomerate and its myriads partners.	Positive - strong ties Positive - strong ties x bridging ties	Knowledge integration, which fully mediates the relationship between SC and ambidexterity
Molina-Morales and Martínez-Fernández, 2009	Survey of 154 Spanish manufacturing firms	Non-significant - Inverted U-shaped relation (strong ties)	Innovation creation
Shu et al., 2012	Survey of 270 firms in China and uses structural equation modelling	Positive - managerial ties Positive - political ties Positive - Knowledge exchange Positive - knowledge exchange and combination Positive - Knowledge combination	Knowledge exchange and combination Knowledge exchange Knowledge combination Product innovation Process innovation

Table 9 - Structural dimension - Network Configuration - Intra-firm

Table 9

Author	***Method and Sample***	***Nature of Relationship and configuration type***	***Dependent variable***
Reagans and McEvily, 2003	Survey of 103 employees of a contract R&D firm located in the US	Positive- cohesive network and network range Positive - structural hole with a strong tie	Ease knowledge transfer Tacit knowledge transfer
Burt, 2004	Survey of supply chain managers	Positive - structural holes	More likely to express ideas, less likely to have ideas dismissed, and more likely to have ideas evaluated as being valuable by senior managers (good ideas)
Rodan and Galunic, 2004	Survey of 106 middle managers in a European telecommunications company	Positive - structural holes Positive - access to knowledge heterogeneity	Overall managerial performance and innovation performance More important for innovation performance than for overall performance
Cummings, 2004	Field study of 182 work groups in a Fortune 500 telecommunication firm	Positive - structurally diverse groups (Members in different locations, who represent different functions, who report to different managers, and who work in different business units)	External knowledge sharing, which is associated with firm performance
Newell, Tansley and Huang, 2004	Exploratory case study (participant observation and semi-structured interviews) on a project team of a large UK global engineering corporation	Positive - bridging and bonding	Knowledge access Knowledge integration
Perry-Smith, 2005	Survey of 109 respondents among researchers in two laboratories of	Positive - heterogeneous set of direct contacts	Mediate the relationship between number of weak ties and creativity

	an applied research institute		
Obstfeld, 2005	Survey and ethnography in an automotive company	Positive - dense social networks and bridging ties	Involvement in innovation
Fleming, Mingo, and Chen, 2007	Analysis of utility patents from inventors	Positive - network density coupled with contacts having diverse expertise	Knowledge generation (number of new subclass pairs within each of a focal inventor's patents)
Bae and Koo, 2008	Agent-based computer simulation model	Positive - dense configuration composed of weak ties	Access to greater amounts of knowledge
McFadyen, Semadeni and Cannella, 2009	Large sample of scientific publications and coauthors over an 11-year period	Positive - tie strength and sparse networks	Knowledge creation (scientific publications)
Tortoriello and Krackhardt, 2010	Survey of R&D scientists and engineers of a large MNE and multidivisional high-tech company	Non-significant - bridging both strong and weak ties across formal organisational boundaries Positive - bridging strong ties embedded in cliques (Simmelian ties)	Innovation generation (respondents filed patents application)
Hotho, Becker-Ritterspach and Saka-Helmhout, 2011	Comparative case study based on participant observation and semi-structured interviews in two subsidiaries of a Dutch MNE in the chemical industry	Positive - structural holes	Knowledge integration
Wei, Zheng and Zhang, 2011	Survey of 390 individuals from 30 teams in a Chinese bank	Positive – density	Transfer of greater amounts of knowledge Attenuate the negative impact of geographical distance on knowledge transfer
Guler and Nerkar, 2012	Global and local patent collaboration ties in the pharmaceutical industry	Negative - global cohesion Positive - local cohesive network with bridging ties	Innovation performance (number of patents leading to new drugs)
Tortoriello, Reagans and McEvily, 2012	Multiple methods. Interviews with R&D managers and researchers and survey with 247 individuals across R&D divisions of a large multinational high-tech company	Positive - network cohesion Positive - network range	Ease of cross-unit knowledge transfer

Table 10 - Structural dimension - Network Configuration - Inter-firm

Table 10

Author	***Method and Sample***	***Nature of Relationship and configuration type***	***Dependent variable***
Hargadon and Sutton, 1997	Case study on a design company	Positive - brokering actor	New ideas and products generated
McEvily and Zaheer, 1999	227 job shop manufacturers located in the US	Positive - bridging ties	Access new information, ideas, and opportunities
Ahuja, 2000	Longitudinal study of firms in the international chemicals industry based on data on collaborative and patenting activity	Positive - cohesive networks Negative - structural holes Contingency based argument	Innovation output (patenting frequency)
Rosenkopf and Nerkar, 2001	Analysis of patenting activity in optical disk technology	Positive - spanning organisational and technological boundaries Negative - non spanning org. and tech. boundaries	Innovation (patents registration)
Edelman et al., 2004	Multiple case study on two companies (Telco and Constructo)	Positive - dense networks Negative - dense networks	Access to unavailable knowledge Knowledge Exploration
Lazer and Friedman, 2007	Agent-based computer simulation model	Positive - network density Negative - network density	Information diffusion Reduce information diversity available, which reduce performance over time
Schilling and Phelps, 2007	Longitudinal study of the patent performance of 1,106 firms in 11 industry-level alliance networks	Positive - closed networks	Knowledge creation (patents count)
Dittrich and Duysters, 2007	In-depth semi-structured interviews and a large scale quantitative analysis of alliance agreements at Nokia corporation	Positive - Dense network Positive - Open network	Exploitation Exploration

Bae and Koo, 2008	Agent-based computer simulation model	Positive - sparse network coupled with strong ties	Knowledge transfer
Tiwana, 2008	Survey of 142 individual and 42 innovation-seeking project alliances	Positive - Strong ties x bridging ties	Knowledge integration
Phelps, 2010	Longitudinal study on networks of 77 telecom equipment manufacturers	Positive - Closed network composed of partners with higher technological diversity	Knowledge exploration (patents citations)
Li, Poppo and Zhou, 2010	Survey data from 168 foreign subsidiaries operating in China	Positive - brokered access (when a major supplier connects the foreign subsidiary to other local suppliers)	Acquisition of explicit but not tacit knowledge

Table 11 - Structural dimension - Centrality - Intra-firm

Table 11

Author	***Method and Sample***	***Nature of relationship and type of centrality***	***Dependent variable***
Ibarra, 1993	Survey in an advertising company	Positive - central people	Willingness to implement (administrative) innovation
Tsai and Ghoshal, 1998	Survey of 15 Business units multinational (MNE) electronics company	Indirect positive effect mediated by trust - central business units	Resource combination and exchange (information, product, personnel, and support)
Tsai, 2001	Survey of 24 business units in a petrochemical company and 36 business units in a food manufacturing company	Positive - central business units	Innovativeness (the number of new products introduced in a unit in a particular year divided by the unit's target number in that year)
Perry-Smith, 2005	Survey of 109 respondents among researchers in two laboratories of an applied research institute	Positive - central position of researchers with few ties outside their labs No effect - central position with	Creativity

		many outside ties	
Nerkar and Paruchuri, 2005	Patents data at DuPont de Nemours, a chemical and pharmaceutical company	Positive - centrality and spanning of structural holes	Influence the selection of knowledge (patents citation data)
Monteiro, Arvidsson and Birkinshaw, 2008	Survey of executives and marketing managers of subsidiaries in 6 MNCs	Negative - peripheral business units	Knowledge (know-how about new products and new services, and marketing best practices) transfer frequency
Paruchuri, 2010	Longitudinal study on inventors networks in eight pharmaceutical companies	Inverted U-shaped relationship - centrality of inventors	Innovation (patents citation)
Fang, Lee and Schilling, 2012	Agent-based computer simulation model	Positive - peripheral and semi-isolated groups in new product development teams	Preservation of new ideas

Table 12 - Structural dimension - Centrality - Inter-firm

Table 12

Author	***Method and Sample***	***Nature of relationship and type of centrality***	***Dependent variable***
Owen-Smith and Powell, 2004	Relational data from a dataset of network connection involving biotechnology firms	Positive - centrality	Knowledge creation (patent counts)
Whittington, Owen-Smith and Powell, 2009	Patent and collaboration database on biotechnology companies in three regions in the US	Positive - global centrality and close proximity to public research organisations Positive - global centrality in the inter-organisational network	Innovation performance (patent counts)
Paruchuri, 2010	Longitudinal study on eight pharmaceutical companies	Positive - centrality	Extend the threshold at which intra-firm centrality becomes negative

Table 13. Additional research suggestions

Rationale for proposed research questions	*Research questions*
Emerging difficulties in operationalising tie strength items in inter-firm studies.	Capaldo (2007) has conceptualised the strength of inter-organisational ties as a three dimensional concept composed of: • a *temporal dimension* (i.e., relationship duration), • a resource dimension or *intensity of collaboration* (i.e., resource commitment or relationship-specific investments), • a *social dimension* (i.e., frequency of the collaboration on joint activities). We believe this conceptualisation deserves empirical validation because it is more fitting to Granovetter's (1973) tie strength theory than other proposed scales (e.g., Rowley *et al.*, 2000).

Lack of studies investigating the relationship between structural SC, knowledge transfer and innovation outputs at the intra-firm level.	Future research could use structural equation modelling techniques to investigate such relationship.
Homophily has been indicated as an important predictor of KT (Möller and Svahn, 2004).	Future research could investigate if tie strength between people of different ethnic groups can affect homophily.
Research lacks the investigation of the factors that determine the development of strong ties	Future research could investigate the influence of factors such as socialisation, mutual interests, likeability and the like.
Research has not investigated the factors that transform a latent tie into a weak tie.	Future research could investigate the factors and strategies that companies and individuals use to access to weak ties.
Recent research has found that a particular type of tie, namely *dormant ties*, can be even more beneficial than strong and weak ties to cheaply accessing to useful and novel knowledge (Levin *et al.*, 2011).	Future research could investigate the influence of dormant ties on KT processes and innovation in a business context, either at the intra-firm or inter-firm level.