Network closure's impact on firms' competitive advantage: The mediating roles of knowledge processes

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ABSTRACT

This study draws on the knowledge management and social network disciplines to examine the effect of network closure on organizations' competitive advantage. We hypothesize that the level of network closure affects an organization's capability of knowledge identification, knowledge transfer, knowledge protection and knowledge institutionalization; these capabilities in turn affect an organization's competitive advantage. Thus, we model network closure as indirectly affecting an organization's competitive advantage. A Partial Least Square (PLS) analysis of the survey data of 78 Chinese petrochemical firms shows that network closure can both enhance and decrease an organization's competitive advantage. Network closure enhances an organization's competitive advantage by facilitating knowledge protection and transfer (via institutionalization), but decreases competitive advantage by hindering knowledge identification. Environmental dynamics that the organizations encounter are observed to moderate the effect of network closure. Combining our results with the findings from the literature, we propose that organizations operating in a dynamic environment, where the domain knowledge is in a state of flux, need to place great importance on knowledge identification; such organizations should choose a sparse network that allows them to receive diverse knowledge. In contrast, organizations operating in a stable environment should opt for a dense network to protect their knowledge and facilitate transfer of required knowledge.

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8 Introduction

Increasingly, organizations have resorted to partnering with external firms to procure the knowledge required to deal with product complexity, to share risks and to realize scale economies (Hamel, 1991). Consequently, organizations, especially small medium enterprises (SMEs), operate in “networks” in order to compete with vertically integrated multinational companies (MNCs). Operating in such a network environment raises the need for management to address the issue of managing the organization’s proprietary knowledge.

Q2 Though researchers such as Nonaka (1995) and Drucker (1993) have recognized that an organization’s knowledge is one of its most important rent-generating resources, this view is true only insofar “that a firm can protect its knowledge from appropriation or imitation by its competitors” (Liebeskind, 1996, p. 95). Organizations in a network environment, where the knowledge can potentially be widely dispersed beyond the organizational boundaries, are vulnerable to having their knowledge expropriated by other firms in the network (Schilling and Steensma, 2001; Powell et al., 1996); these organizations risk failing to protect and deploy the unique knowledge that sustains their competitive advantage (Barney, 1991).

A number of recent studies have examined the difficulties of managing knowledge within a dyadic relationship. Larsson et al. (1998) model a strategic alliance between two partners as a non-cooperative game to show how selfish partners may exploit the alliance. Kale et al. (2000) suggest that an organization balance its need for knowledge with the desire to protect its own knowledge in a dyadic relationship by developing relational capital that supports the appropriate conflict management approaches. Oxley and Sampson (2004) observe that some firms restrict the scope of their alliance activities to protect their core knowledge in dyadic relationships. All these dyadic level studies, however, do not account for attributes of the multiparty network that are important in the knowledge management context. One such attribute is network closure, that is, the extent to which organizations are connected to each other in the network. Brass et al. (2004), in their review of extant research on the antecedents and consequences of networks, discover some studies which find that a high degree of network closure is salient to innovativeness, while other studies view a low degree of network closure as salient. Some light is thrown on the issue by Obstfeld (2005) who observes that a dense network facilitates incremental innovation but not radical innovation. A more detailed study is thus needed to address the question of how network closure affects organizations’ competitive advantage from a knowledge perspective.

We address the question by studying a sample of organizations that are part of a network to examine how network closure impacts knowledge identification, transfer, institutionalization and protection and the subsequent effects on their competitive advantage. In this study network closure refers to the degree of inter-connectivity of the focal organizations’ close partners. A network with high closure implies that organizations in the network are well connected with each other. In contrast, a network with low closure means the connectivity among the organizations is low; such a network is known as a sparse network. We focus on the technical relationships between the focal organizations and their partners, as well as the technical relationships among these partners. Our fine-grained analysis revealed the positive as well as the negative effects of network closure on organizations’ competitive advantage. By taking a knowledge perspective, our work sheds light on how organizations may gain knowledge from their partners but at the same time protect their hard-earned knowledge (Sorenson and Wageespack, 2005).

Review of the literature

Some researchers have examined the influence of network characteristics on an organization’s access to knowledge based on the assumption that such access is the key to superior organizational performance. Tsai (2001, p. 997) argues that network centrality allows an organization to access external information and knowledge helpful to a business unit’s innovativeness and business performance. Baum et al. (2000, p. 270) have found that the size of the alliance network for biotechnology startups is indicative of the ‘efficiency’ of the network in achieving high performance. A large network provides “access to strategic and operational know how . . . with minimum costs of...
redundancy, conflict and complexity”. Shan et al. (1994) argue that a startup’s access to resources and information from cooperative relationships makes the number and range of such relationships important to innovation output.

Similarly, Soh and Roberts (2005) conclude that both the number of cooperative relationships and the centrality of a firm in the U.S. computer networking market are positively related to innovation performance as these relationships provide experience and knowledge to the focal organization. While the above studies show the relationship between information access and firm performance, they fail to consider the process by which such access is translated into firm performance. Knowledge access and identification are assumed to be the causal mechanism linking network structure to performance; the intermediate stages of knowledge management such as knowledge transfer, institutionalization and protection are ignored.

Studies that look specifically at the effect of network closure on firm performance yield contradictory results. Trust appears to be a key theme of studies that find a positive effect of network closure. Trust generated among the actors in a closed network is found to ease information access and the transfer of knowledge to facilitate innovation. Such an effect was first observed at the individual level in family and community settings by Coleman (1988). A similar effect holds true for individuals acting in a business setting (Reagans and McEvily, 2003). Ahuja (2000) extends the theme of trust to the organizational level by arguing that organizations in a closed network have an incentive to behave in a trustworthy manner because “in closed networks, … information about one actor’s opportunistic acts diffuse rapidly to other related actors, and sanctions for deviant behavior are more easily imposed” (p. 432). Indeed, a recent study by Santoro and Sarapito (2003) shows that trust in a closed network facilitates knowledge identification as well as knowledge transfer.

In contrast, the negative side of a closed network is revealed by Uzzi (1997) who notes that embedded ties prevalent in such networks decrease the width of the search range which can hinder innovation. In the same vein, Burt’s (1992) points that organizations embedded in sparsely connected networks enjoy efficiency and brokerage advantages based on their ability to arbitrage non-redundant information exchanges is an argument against closed networks. In summary, while some researchers observe a positive effect of network closure on innovation, other researchers observe an opposite effect.

Recent efforts to reconcile this contradiction focus on the roles that network closure play on different facets of knowledge management. Burt (2000) argues that a high level of network closure helps organizations to transfer knowledge, while a low level of network closure allows organizations to access novel knowledge. Baum and Ingram (2000) note that a closed network facilitates knowledge exploitation, while a sparse network eases knowledge exploration. The contradictory findings of the effect of network closure on organization performance in the extant literature reveal a need for a closer examination.

We approach this problem by building a fine-grained framework that inserts the knowledge management processes between the network closure-organization performance link. Knowledge management processes refer to knowledge identification, transfer, institutionalization and protection. Given the importance of industry and organization setting, our study also takes into account the possible moderating effects of the environment as well as the social integration mechanism. Indeed, social factors such as culture have been identified as a possible future topic by Argote et al. (2003).

Hypotheses development

To open up the black box between network closure and organizations’ competitive advantage, we adopt the knowledge based view of the firm (Grant, 1996). According to this perspective, organizations derive their competitive advantage based on their knowledge management capability (Seely-Brown and Duguid, 2000; Nonaka and Takeuchi, 1995). Following the process approach used in the knowledge management research (Alavi and Leidner, 2001), we examine the effects of network closure on an organization’s knowledge identification, knowledge transfer, knowledge institutionalization and knowledge protection.

Similar to Burt (2000) and Marsden (1990), network closure is proxied by the percentage of close relationships out of all possible relationships among the focal organization’s partners. We use...
technological knowledge flows as the basis for the presence of relationships between network actors. In order to make our hypotheses comparable with previous studies, we take strategic flexibility, innovation and performance as the three proxies for an organization's competitive advantage (Barney, 1991; Zahra and George, 2002).

Network closure, knowledge identification and organization competitive advantage

Network closure and knowledge identification

Organizations operating in a relatively uncertain environment characterized by rapid innovations and shifting strategic imperatives must be able to identify new knowledge to make sense of the environment. However, this task is hard to achieve when strong social norms in a closed network hinder knowledge identification by curtailing deviant behavior that may help the knowledge search process. This curtailment of potentially useful deviant behavior results in the suppression of innovation (Coleman, 1988). Moreover, learning is difficult when the uniformity in thought and behavior among long standing partners in the same network (Galaskiewicz and Wasserman, 1989) result in all the network players holding the same information. This redundancy of information limits an organization's access to divergent perspectives (Burt, 1992, 2000) that are necessary for an effective response in a dynamic environment. We thus note that network closure is negatively related to the organization's capability in identifying new knowledge. Therefore, our first is:

H1a. Network closure has a negative effect on knowledge identification.

Knowledge identification and competitive advantage

Ahuja and Lampert (2001) note that organizations fail to create radical innovations when they fall into three types of competence traps, namely, the familiarity trap (favoring familiar technologies), maturity trap (favoring mature technologies) and propinquity trap (favoring solutions that are close to existing ones). Therefore, organizations must actively explore novel, emerging and pioneering technologies to avoid such traps. Such active exploration can provide organizations with the ability to track changes in the industry, facilitate the development of necessary capabilities to exploit new technological opportunities necessary to respond to the changes (Coleman et al., 1990) and avoid being blindsided by potential industry-transforming innovations (Zahra and George, 2002). Furthermore, the ability to identify new relevant knowledge rapidly may help organizations exploit this knowledge ahead of competition to reap the first-mover advantage and to respond quickly to customer needs (Kodama, 2005). In brief, an organization's capability in identifying new knowledge from its external environment helps it avoid competence traps, open more windows of opportunity to exploit new technologies as well as provide potential first-mover advantages and quick responses to customer needs. Organizations with higher capability in knowledge identification are therefore more likely to achieve higher competitive advantages. Therefore, we propose that:

H1b. Knowledge identification has a positive effect on a firm's competitive advantage.

Taking the two causal relationships H1a and H1b together, we note that a closed network's negative effect on an organization's ability to identify new knowledge will in turn hinder the firm's access to new knowledge necessary to achieve competitive advantage. Put formally,

H1c. Mediated by knowledge identification, network closure has a negative effect on a firm's competitive advantage.

Network closure, knowledge protection and competitive advantage

Network closure and knowledge protection

In general, knowledge is difficult to protect because it is difficult for an organization to detect the expropriation or illegal imitation of its knowledge (Liebeskind, 1996). This difficulty is compounded for organizations in a sparse network when the absence of third-parties around certain dyads in the network leaves partner behavior unmonitored. The probability of getting caught and punished is too low.
low to serve as a discouragement for appropriating knowledge. As a counter-example, consider three organizations, A, B and C in a closed network. Organization A sharing its knowledge with organizations B and C in a closed network can be assured that the existence of a relationship between organization B and organization C allows them to mutually monitor one another about the use of organization A’s knowledge. Unauthorized appropriation by either B or C can easily be detected and the offending party collectively punished by organizations in the network. Besides the monitoring effect, Kreps (1990) suggested that partner behaviors in a closed network are controlled by the reputation effect; an actor is less likely to cheat an alliance partner as their actions will be disseminated widely in the network. The absence of monitoring, punishment and reputational effects in a sparse network will hence result in greater difficulty in protecting knowledge.

Grant and Baden-fuller (1995) note that since it is impossible to control a partner’s conduct by threat alone, the mere ability to monitor and punish partners’ unauthorized knowledge expropriation is insufficient to protect knowledge. Instead, such unauthorized knowledge expropriation can also be avoided by increasing the level of trust that strengthens cooperation (Ring and Van de Ven, 1994). Zaheer et al. (1998) find that trust reduces the level of inter-organizational conflict and enhances an organization’s ability to both learn and protect its knowledge (Kale et al., 2000). Nooteboom and Noorderhaven (1997) and Laere and Heene (2003) note that a closed network provides time and a common context for developing the familiarity and mutual understanding that engender trust. Therefore, the higher level of trust that is expected in a closed network will enhance an organization’s ability to protect their proprietary knowledge within a network. In summary, a network with high closure could discourage deviant actions and generate trust among network actors, thus providing effective knowledge protection compared to a network with low closure. Therefore, we propose that:

H2a. Network closure has a positive effect on knowledge protection.

Knowledge protection and competitive advantage

An organization that can protect its knowledge through patents or other means is likely to enjoy a higher competitive advantage. This is well illustrated by pharmaceutical companies where the presence of patent protection helps them enjoy a significant advantage over their competitors. Matusik and Hill (1998) suggest two ways in which the failure to protect knowledge can negatively affect an organization’s performance. First, any differential advantage that can be obtained by the application of proprietary knowledge is negated when the ease of competitive imitation creates an elastic demand regime. Second, the exploitation of knowledge spillovers by imitators allows them to lower their cost of innovation and offer similar innovation more cost effectively. In industries with a weak appropriability regime, organizations may use isolating mechanisms to impede imitation (Rumelt, 1987; Zahra and George, 2002). However, the disadvantage of using these mechanisms is that they tend to hinder innovation by closing off avenues for the organizations to escape from competence traps. In brief, organizations with superior knowledge protection capabilities are expected to derive economic benefits from their innovation leading to the achievement of competitive advantages that their peers who cannot protect knowledge cannot match. Therefore, we hypothesize that:

H2b. Knowledge protection has a positive effect on a firm’s competitive advantage.

Taking H2a and H2b together, we thus have:

H2c. Mediated by knowledge protection, network closure has a positive effect on a firm’s competitive advantage.

Network closure, knowledge transfer, knowledge institutionalization and organization competitive advantage

Network closure and knowledge transfer

Frequent interactions among members of a closed network can increase the level of trust between the network members. Members of such a closed network can also be assured that the presence of strong common third-party ties will encourage members to avoid behaviors that can bring a bad
reputation upon themselves as such as a reputation can develop quickly in the presence of the common
ties. Such a “peer-monitoring” effect that allows violations to be detected and punished quickly
lessens the risk for actors in the network to trust one another (Coleman, 1990). When there is a high
degree of trust among partners, there will be a greater degree of knowledge exchange (Tsai and
Ghoshal, 1998; Mayer et al., 1995). The presence of trust also reduces the cost of knowledge transfer by
minimizing conflict and the need to verify information (Zaheer et al., 1998). Dahl and Pedersen (2005)
have found that long term relationships based on trust and reputation are channels of valuable
knowledge. In addition, network closure also provides useful redundant information because of the
frequent and repeated interactions among a group of common members. Accessing multiple and
redundant information sources reduces the noise in the communication (Mayer et al., 1995) as the
multiple sources provide the recipient with the ability to triangulate among the sources to evaluate
the validity and usefulness of the knowledge and transfer it more efficiently. Thus, we note that
network closure is positively related to the focal organization’s knowledge transfer from its network
partners. Put formally,

H3a. Network closure has a positive effect on knowledge transfer.

Knowledge transfer, institutionalization and competitive advantages

External knowledge is usually first received by a small group of employees before being
disseminated to other employees. The knowledge transferred may not benefit the receiving
organization if other employees who can put the knowledge transferred into good use are unaware of
or have no access to the knowledge transferred. In addition, the knowledge transferred must be
integrated into the organization’s existing knowledge base to build up its better competitive
advantage. According to Tallman et al. (2004), knowledge acquired from external partners is largely
component knowledge. The organization-specific architectural knowledge of the external partners
remains private. This has to be so since it is the manner in which the component knowledge is
integrated and employed according to organization-specific architectural knowledge that leads to
lasting competitive advantage (Matusik and Hill, 1998). Likewise, the receiving organization must
integrate the component knowledge into its specific architectural knowledge base to benefit from the
knowledge received. Therefore, the presence of internal knowledge sharing mechanisms and
incentives to institutionalize the acquired external knowledge are needed. We hypothesize that:

H3b. Knowledge institutionalization has a positive effect on a firm’s competitive advantage.

Social integration as moderator in the knowledge transfer–knowledge institutionalization link

A recent study by Patnayakuni et al. (2007) on information systems development reveals that social
integration is an important facet of the knowledge transfer–institutionalization link. For knowledge
institutionalization to take place, social integration mechanisms must exist to embed the transferred
knowledge into the organization’s architectural knowledge. After all, it is the architectural knowledge
that contributes most to an organization’s long term competitive advantage (Matusik and Hill, 1998).
Social integration mechanisms refer to practices that can help employees share their knowledge.
According to Zahra and George (2002), informal (e.g. internal social networks) and formal (e.g.
communication structure, gatekeeper) social integration mechanisms lower the intra-organization
barriers and facilitate the transformation process from transferred knowledge to leveraged and
exploitable knowledge.

Jones et al. (2003) found that, while salespersons were important receiving points for external
knowledge, it was the top management’s emphasis on alliance learning and the incentive to learn that
helped the relevant employees convert the transferred knowledge into the organizational knowledge
that can lead to superior competitive advantage. Indeed, Takeuchi and Nonaka (1986) observed that
introducing organization-wide knowledge sharing programs (e.g. multidisciplinary teams for new
product development) can result in corporate level integrated learning. We therefore posit that
transferred knowledge is more easily transformed into institutionalized knowledge in organizations
with a high social integration mechanism compared to another with a low social integration
mechanism. The above arguments lead us to formulate the following hypothesis:

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H3c. Social integration positively moderates the effect of knowledge transfer on knowledge institutionalization.

Environmental dynamics as a moderator of the knowledge identification–competitive advantage relationship and knowledge protection–competitive advantage relationship

Environmental dynamics, which refers to the rate of technological change and length of the product life cycle experienced by organizations, can moderate the effects of knowledge identification on organizations’ competitive advantage. Organizations in a dynamic environment must identify new knowledge in order to respond swiftly to the environmental changes as existing knowledge can become obsolete in a changing environment (Rowley et al., 2000). The swift responses needed to keep an organization’s knowledge stock updated in order to avoid potential technology lock-out under such unstable circumstances demand that organizations be alert to shifts in the external environment. In contrast, environmental scanning for new knowledge and industrial trends would be less crucial for an organization operating in a stable environment characterized by clear directions about the future and few environmental disturbances. Therefore we hypothesize that:

H4a. Environmental dynamics positively moderate the effect of knowledge identification on competitive advantage.

Environmental dynamics also moderate the importance of knowledge protection. In a dynamic environment characterized by rapid technological change and short product life cycles, organizations need to place relatively more importance on developing and upgrading their knowledge compared to protecting existing knowledge (Matusik and Hill, 1998). This is because the rapidly changing technological environment can render existing knowledge obsolete very quickly. Therefore, it would not be prudent to assign priority to protect the existing knowledge, which will be outdated soon, over the search for relevant knowledge.

According to McEvily et al. (2004), some organizations adopt rapid innovation as their protective mechanism towards knowledge appropriation by partners. Such a strategy of rapid innovation makes sense in a dynamic environment where partners who may potentially appropriate the technology need considerable lead time to develop their own architectural knowledge and market channels to exploit the acquired component knowledge. In a dynamic environment, the time available for knowledge appropriation is short since the next technology cycle arises quite rapidly, making the potential return from the appropriation of existing technologies low. In summary we propose that:

H4b. Environmental dynamics negatively moderate the effect of knowledge protection on competitive advantage.

Research methodology: data collection and samples

As the focus of the present study is on the technical connection between organizations in a network and the internal knowledge management practices, an ego-network design is an appropriate approach to obtain organization-specific information. In such a design, one begins with a selection of focal nodes (egos) and identifies the nodes to which they are connected (alters). Then, respondents from ego organizations will determine which of the identified alters are connected to one another. This approach is effective for collecting a form of relational data from very large populations and can be implemented by survey methods (e.g. Soh and Roberts, 2004; Batjargal, 2005). Here, we consider only ties in the network resulting from the technological knowledge flows of the organizations which have responded to our survey.

A large scale survey of firms from the Chinese petrochemical industry has been conducted with the help of two staff members of the China Petroleum and Chemical Industry Association (CPCIA). We limit the survey to firms operating in the downstream activities of the petrochemical industry as our interviews with industry experts conducted prior to the survey show that these companies, when compared to their upstream counterparts, are characterized by their knowledge intensity. Furthermore, the industry is mature enough to have a clearly defined industry boundary and
contain stable relationships among players. Finally, organizations within the industry rely on partnerships to acquire technical knowledge because of the intense competition and dynamic environment.

We adopted the four iterative steps for developing instruments suggested by Churchill (1979): (1) the instrument was reviewed by a panel of professors and research students; (2) a pretest was then conducted with local business practitioners; (3) an item-by-item debriefing was carried out with two experienced CPCIA staff members who completed the survey and (4) a pilot study was implemented through email with another 10 experienced managers from the industry. We then randomly selected 1000 firms from the CPCIA database for our data collection. Out of the initial batch of 1000 mailings, 207 were undeliverable.

The remaining 793 mailings yielded 30 responses. Twenty of the 30 responses were complete and usable. A reminder sent to the non-respondents through email about three weeks after the distribution of the first mailing yielded an additional five complete and usable responses. To increase the response rate we conducted telephone interviews with non-responding firms to collect additional data one month after the email notice. The interviews typically took 30–45 min. We followed Judd et al.’s (1991) advice not to bias informants’ judgments by being careful not to signal our expectations about the responses or the hypotheses of the study. This helped to ensure consistency with the paper-based questionnaires. The telephone interviews generated 53 responses. After conducting the Kruskal–Wallis test where we found some differences in the responses between the two methods, we included this collection method as a control factor in our data analysis.

In total, we have 78 usable responses giving us a reasonable overall response rate of 9.83%. Fiftyseven (73.1%) of the 78 firms were small firms with <250 employees. In total, 65 (83.3%) informants are in senior management positions with job titles such as CEO, General Manager, Chief Technology Officer or Project Manager and 44 (56.4%) have more than five years experience in the firm. Some respondents have a short period of experience with the existing company compared to those in western companies; this is, however, expected as executives in China change jobs more frequently compared to their western counterparts. Given that we asked respondents to provide information on their current or recent technical collaborators, we believe respondents with at least 1 year experience (or 93.6% of our respondents) should be in a good position to answer the questionnaire. In addition, given that a high number of respondents are senior managers in their organizations, we believe the informants have sufficient knowledge to respond accurately to the questionnaire.

**Measurement model**

The questionnaire was constructed using existing measurement items (see Appendix I). To identify a firm’s network, we asked the respondents to list whom they work closely with on technical projects currently or in the immediate past. Specifically, we stated “regarding your last collaborative project and/or ongoing project with technical partners, please list 3–4 names that you have the most intensive technical knowledge exchange with”. They were then asked to indicate the presence of technical relationships among their technological partners. The procedure of name generators and name interpreters followed the practice of Marsden (1990) and Burt (1992). Network closure was then measured as the sum of the existing ties in the ego network divided by the number of all possible ties in the ego’s network (Marsden, 1990). An example of network closure calculation is shown in Appendix I. All the measurements were adopted from previous studies. For the reasons explained below, measurements for the knowledge transfer, competitive advantage and environmental dynamics constructs were modelled as formative, while those of knowledge identification, knowledge institutionalization, knowledge protection and social integration were modelled as reflective measures.

Reflective measures were correlated and unidimensionally represent the latent construct. In contrast, formative measures collectively form the latent construct and represent different dimensions of it. An example of formative measures, as illustrated by Chin (1998a), is the amount of beer, wine and hard liquor consumed as indicators of mental inebriation. Alternatively, mental inebriation can be modelled as reflective measures through measures such as blood alcohol level, driving ability and MRI brain scan which are correlated with each other. That is, an increase in the...
blood alcohol level measure would also imply an increase in the inability to drive and other measures since they are all meant to tap into the same phenomenon. In contrast, an increase in beer consumption does not imply similar increases in wine or hard liquor consumption, MacKenzie and Podsakoff (2003) provide a detailed review of the differences between these two types of variables and the need to conduct the right statistical analysis based on the measures adopted. According to Jarvis et al. (2003), “failure to correctly specify the measurement model can lead to different conclusions about the empirical relationships between latent constructs” (p. 216). Control variables organization size and R&D investment were measured as the log – number of employees and log – actual investment respectively.

In this study, we used the “Knowledge Transfer” construct developed by Szulanski (1996) as a reflection of different dimensions of both knowledge sources and a recipient’s attributes. It is completely conceivable that the measures do not co-vary. For example, a focal firm could be very capable of absorbing a source’s technological knowledge (i.e., high score on measurement item #2) while, unfortunately, its alter partners are not willing to share their knowledge (low score on measurement item #1). Therefore we modelled knowledge transfer as formative measures.

The construct “Competitive Advantage” was measured using three dimensions, i.e., innovativeness, strategic flexibility and financial/market performance. While it is possible for strong correlations to exist among these three dimensions, they may not necessarily co-vary. For instance, many small firms possess a high flexibility in shifting their main products to suit emerging market niches while placing lower emphasis on technological innovation due to limited resources. We therefore treated measures of innovativeness, strategic flexibility and performance as formative indicators of competitive advantage.

This modelling approach is preferable to a second order modelling, that is, a “Molar” model where first order constructs are treated as formative “indicators” for a higher order latent variable (as discussed extensively by Chin and Gopal, 1995 and Bagozzi, 1985), because our approach “avoids the complexity of a second-order factor model while ensuring that constructs are generalizable across different contexts” (Gray and Meister, 2004, p. 827 footnote 3). Given that different industries place different value on the three dimensions of competitive advantage, this way of formative modelling is justified. Note that the individual measures for innovativeness, strategic flexibility and performance are modelled as reflective as they are expected to co-vary within their dimension.

We characterized “Environmental Dynamics” by the product life cycle, how fast the technology changes and how difficult it is to forecast the future technology. The construct is a formative one with three items. Two of the items are from Jaworski and Kohli (1993) with the third developed by the authors. The first item relates to the product life-cycle, the second item relates to the pace of technology changes, and the third item measures the ease of forecasting technology changes in the industry. These indicators are viewed as defining characteristics of the construct “Environmental Dynamics” whereby changes in the indicators are expected to cause changes in the construct, however, a change in the value of one of the indicators is not necessarily expected to be associated with a change in all of the other indicators (i.e., it is not necessary that these items will co-vary).

We illustrate this with examples of the current situation in the television and mobile phone industries. At this juncture, the product-life cycle of a television is short but it is not that difficult to forecast the direction of the technology (i.e., improving the LCD technology to have a faster response rate, greater resolution, etc.). However, in the mobile phone industry, the product life-cycle is equally short but it is harder to forecast the direction and development of the technology involved (e.g. it might be 3G, W-CDMA, etc.). Even within the same industry, different companies will experience different dynamics depending on factors such as R&D capability and market position.

The other constructs, namely knowledge identification, knowledge institutionalization, knowledge protection and social integration, are modelled as reflective measures. For knowledge identification, we adopted the 3-item measures developed by Rowley et al. (2000). The measures for knowledge institutionalization are based on Szulanski (1996). For knowledge protection, we followed the two items developed by Kale et al. (2000) and the construct social integration is based on Zahra and George (2002) (see Appendix I for the measurement items).

Following researchers like Wang et al. (2004), Talke (2007) and Dong et al. (2008), we analyzed our model using the structural equation model (SEM) as implemented in Partial Least Square (PLS) Graph...
3.0. According to Chin et al. (2003), PLS Graph 3.0 can model latent constructs under conditions of non-normality for small to medium size samples. Our sample of 78 responses meets the minimum sample size of 60 required by PLS Graph 3.0 for our model. According to Chin and Newsted (1999), the sample size should be the larger of two possibilities: (1) the block with the largest number of formative indicators (i.e., largest measurement equation) or (2) the dependent latent variable with the largest number of independent latent variables impacting it (i.e., largest structural equation).

If one uses a regression heuristic of 10 cases per predictor, the sample size requirement would be 10 times either (1) or (2), whichever is greater. In our study, the block with largest formative indicators was the competitive advantage, which incorporated 6 formative indicators, and the dependent latent variable with the largest number of independent constructs impacting it was also competitive advantage, which was impacted by 6 constructs. Therefore, our sample size of 78 satisfies the required minimum of 60 required by our research design.

Moreover, assuming a large effect size requires \( f^2 = 0.35 \), which in variance terms amounts to an \( R^2 \) or partial \( R^2 \) of 0.35/1+0.35 = 0.26 (Cohen, 1988). As shown by the PLS analysis, the current model achieves a higher \( R^2 \) (0.54 for competitive advantage) and, therefore, it is safe for one to assume a large effect size for the studied population. Hence, our dataset with \( N=78 \) and \( u=6 \), \( v=N-u-1=71 \) and \( \lambda = f^2 \times N = 0.35 \times 78 = 27.3 \) could achieve a statistical power of approximately 0.92 at \( a=0.01 \), which is higher than the typical 0.80 rule.

Hulland (1999) suggests three construct reliability tests for PLS analysis, namely, item reliability, convergent validity and discriminant validity. Item reliability, however, is not a meaningful concept for the three formative constructs in the current study, knowledge transfer, environmental dynamics and competitive advantage (Cohen and Levinthal, 1990), given that there is no assumption that the formative indicators within these constructs will co-vary (Chin, 1998b). However, the three constructs that make up competitive advantage, namely innovativeness strategic flexibility and performance, each have their own reflective measures that co-vary. They are therefore included in the exploratory factor analysis (EFA) conducted to test the item reliability of the indicators and identify items that cross-load on other constructs (Gray and Meister, 2004). One item each from strategy flexibility and performance were dropped due to unclear loading. Table 1 shows the item loadings on the reflective constructs and the composite reliabilities with items that did not load on the intended factor at the 0.7 level trimmed (Hulland, 1999). Convergent validity of the measures is supported by the average variance extracted (AVE) for all the constructs shown in Table 1 being above the acceptable threshold of 0.5 (Chin, 1998b).

As suggested by Fornell and Larcker (1981), discriminant validity was verified through the examination of the square roots of AVE scores of the constructs. Table 2 confirms the discriminant validity of constructs used in the current study, as demonstrated by the value of the square roots of AVE scores (shaded cells), being greater than the correlations involving the constructs (same column and same row, off-diagonal cells), implying that each construct shares larger variance with its own measures than with other measures.

Following Podsakoff et al. (2003) and Liang et al. (2007), the effect of the common method bias was estimated by a “method factor”. The “method factor” is a construct with indicators comprising all principal constructs’ indicators. The inclusion of this construct allows each of our indicator’s variances to be substantively explained by the principal construct and by the “method factor”. Our results show

<table>
<thead>
<tr>
<th>Construct</th>
<th>No. of items</th>
<th>Response mean (1–7)</th>
<th>Standard deviation</th>
<th>Composite reliability</th>
<th>Average variance extracted (AVE)</th>
<th>Item loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge identification</td>
<td>3</td>
<td>4.27</td>
<td>1.05</td>
<td>0.87</td>
<td>0.69</td>
<td>0.90, 0.82, 0.77</td>
</tr>
<tr>
<td>Knowledge institutionalization</td>
<td>2</td>
<td>4.01</td>
<td>1.11</td>
<td>0.89</td>
<td>0.80</td>
<td>0.92, 0.86</td>
</tr>
<tr>
<td>Knowledge protection</td>
<td>2</td>
<td>4.04</td>
<td>1.24</td>
<td>0.91</td>
<td>0.83</td>
<td>0.91, 0.91</td>
</tr>
<tr>
<td>Social integration</td>
<td>3</td>
<td>4.12</td>
<td>1.16</td>
<td>0.90</td>
<td>0.74</td>
<td>0.84, 0.88, 0.87</td>
</tr>
<tr>
<td>Innovativeness</td>
<td>2</td>
<td>4.10</td>
<td>1.19</td>
<td>0.94</td>
<td>0.88</td>
<td>0.94, 0.94</td>
</tr>
<tr>
<td>Strategic flexibility</td>
<td>2</td>
<td>3.99</td>
<td>1.17</td>
<td>0.86</td>
<td>0.75</td>
<td>0.85, 0.89</td>
</tr>
<tr>
<td>Performance</td>
<td>2</td>
<td>3.87</td>
<td>1.37</td>
<td>0.91</td>
<td>0.83</td>
<td>0.89, 0.93</td>
</tr>
</tbody>
</table>

that the average variance of indicators explained by substantive constructs is 0.722, whereas the method factor explains only 0.012 of the variance. In addition, only two out of 23 “method factor” loadings are significant. Given the small magnitude and insignificant variance explained by the “method factor”, we can safely say that the common method bias will not adversely affect the validity of this study.

**Results**

The adequate measurement model (high item reliability, convergent validity and discriminant validity) of our construct allows us to proceed to employ them in our estimation of the structural model to test our hypotheses. The significance of hypothesized direct relationships (H1a, H1b, H2a, H2b and H3a) is evaluated by examining the magnitude and significance of the path coefficients computed by PLS Graph 3.0. Table 3 shows the results of hypotheses H1a, H1b, H1c, H2a, H2b and H2c. Hypothesis 1a is supported with significant path coefficients of −0.34 (p < 0.01), but not H1b. Hypotheses 2a and 2b are also supported with significant path coefficients of 0.41 (p < 0.01) and 0.36 (p < 0.05) respectively. To understand why H1b is not supported, we conducted post hoc analysis by examining the effect of knowledge identification on the three competitive advantage components, i.e., strategic flexibility, innovativeness and performance, individually. Our results show that, while knowledge identification indeed has no effect on strategic flexibility and performance, it has a significant effect on innovativeness (path coefficient 0.42, p < 0.01).

Table 3

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Path coefficient</th>
<th>T statistics (z for H1c and H2c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1a</td>
<td>−0.34***</td>
<td>2.87</td>
</tr>
<tr>
<td>H1b</td>
<td>0.13</td>
<td>0.59</td>
</tr>
<tr>
<td>H1c</td>
<td>−0.044</td>
<td>−0.59</td>
</tr>
<tr>
<td>H2a</td>
<td>0.41***</td>
<td>4.59</td>
</tr>
<tr>
<td>H2b</td>
<td>0.36**</td>
<td>2.13</td>
</tr>
<tr>
<td>H2c</td>
<td>0.15</td>
<td>1.91</td>
</tr>
<tr>
<td>H3a</td>
<td>0.34**</td>
<td>2.42</td>
</tr>
<tr>
<td>H3b</td>
<td>0.20</td>
<td>1.45</td>
</tr>
</tbody>
</table>

* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.
One possible explanation why knowledge identification has a positive effect on innovativeness but not strategic flexibility and performance may be due to the nature of the sample in our survey. The majority of our respondents are small firms with 250 or fewer employees. Compared to large firms, small firms lack the resources to conduct R&D internally and, therefore, rely heavily on the ability to identify the latest technological developments and relevant knowledge then translate this knowledge into innovative products. In small firms, strategic flexibility is largely dependent on the capability and the strategy set by the top management of the company rather than their ability to identify knowledge. Similarly, compared to large firms, the performance of small firms is heavily influenced by factors such as competitive intensity and other environmental factors rather than the ability to identify knowledge.

Hypotheses 1c and 2c examine the mediating effects of knowledge identification and protection between network closure and organization competitive advantage. We adopt the mediation analysis techniques of Subramani (2004) and Hoyle and Kenny (1999) to estimate the magnitude of the mediated paths based on the product of the magnitude of the product of the standardized values of the individual direct paths. For the mediated path from network closure through knowledge identification to competitive advantage, we assume that network closure $\rightarrow$ knowledge identification has a standardized path coefficient $x$ and standard error $S_x$ and knowledge identification $\rightarrow$ competitive advantage has a standardized path coefficient $y$ and standard error $S_y$. Following Subramani (2004) and Hoyle and Kenny (1999), such an individual mediated path coefficient is assessed by calculating the product of the standardized path coefficients of the direct effects $(x \times y)$ and the standard error of the mediated path coefficient can be estimated as $S_{ab} = \sqrt{(y^2S_x^2 + x^2S_y^2 + 2xyS_xS_y)}$. As the path coefficients are standardized, a z-test is adopted for testing the significance of the paths where $z = (x \times y)/S_{ab}$.

Our results show that H2c is supported but not H1c. This is not surprising since H1b was found to be insignificant. Nonetheless, since our fine-grained analysis of H1b shows that knowledge identification has a significant effect on innovativeness but not strategic flexibility, we tested the path network closure $\rightarrow$ knowledge identification $\rightarrow$ innovativeness. This relationship was found to have a path coefficient of $-0.144$ ($p < 0.01$, $z=2.42$). It is noted that the coefficient of the mediating path of network closure $\rightarrow$ knowledge identification $\rightarrow$ innovativeness is negative while that of network closure $\rightarrow$ knowledge protection $\rightarrow$ competitive advantage is positive.

This suggests that the mediated effects from network closure to competitive advantage attenuate each other to a certain extent. This result is consistent with other researchers who have highlighted both the advantages (e.g. Kreps, 1990; Kale et al., 2000) and disadvantages (e.g. Galaskiewicz and Wasserman, 1989; Burt, 1992) of a closed network. The current study has, however, shown how the contradictory effect of network closure on competitive advantage can arise from the mediated effects resulting from organizations trying to manage their knowledge assets.

Our analysis also shows that Hypothesis 3a is supported with a path coefficient of 0.34 ($p < 0.01$) and Hypothesis 3b is supported with a path coefficient of 0.20 ($p < 0.1$). Hypotheses 3c, 4a, and 4b focus on the moderating effects of social integration mechanisms and environmental dynamics. Following Gray and Meister (2004), these moderating effects were modelled by creating an interaction term that comprises the cross products of the standardized scores of the measurement items of the moderator and the variable whose impact it moderates (Aiken and West, 1991; Chin et al., 2003). For example, to examine how the level of the social integration mechanism affects the knowledge transfer $\rightarrow$ knowledge institutionalization relationship that is the focus of Hypothesis 3c, we create a new interaction term denoted as social integration $\times$ knowledge transfer. As social integration has three items and knowledge transfer has four items, a total of 12 items are used for the interaction term social integration $\times$ knowledge transfer.

Fig. 1 and Table 4 show the results of the analysis of the moderating effects. The moderator social integration has a significant path coefficient of 0.37 on the knowledge transfer $\rightarrow$ knowledge institutionalization relationship ($t=2.75$, $p < 0.01$). This positive path coefficient shows that H3c is supported, i.e., the higher the level of social integration, the greater the effect of knowledge transfer on knowledge institutionalization. An organization in a closed network that facilitates knowledge...
transfer will experience a positive benefit from being able to institutionalize the transferred knowledge under high social integration.

Given this positive and significant moderating effect (H3c) but insignificant knowledge transfer → knowledge institutionalization path (coefficient = 0.16, p > 0.1 as shown in Fig. 1), we took a closer examination by carrying out a post hoc analysis. We divided the data on social integration capabilities into low, medium and high levels. As the scores for social integration were standardized by PLS Graph, we employed a \( \frac{1}{2} \) cut-off to produce three groups so that each would be large enough for a meaningful comparison regression test (Gray and Meister, 2004).

The results in Table 5 show that knowledge transfer → knowledge institutionalization is significant for companies with medium or high levels of social integration capabilities. This shows that H3c is supported when social integration exceeds a certain level. Putting the results of H3a, H3b and H3c together, we can logically conclude that the positive effect of network closure on an organization’s competitive advantage through its positive impact on knowledge transfer is only effective when the transferred knowledge is transformed into institutionalized knowledge due to the presence of social integration mechanisms.

We used the same procedure to test the moderating effects of environmental dynamics on the knowledge identification → competitive advantage link and on the knowledge protection → competitive advantage link. The results are shown in Fig. 1. The moderator environmental dynamics has a positive effect on the knowledge identification → competitive advantage link as predicted in

### Table 4

<table>
<thead>
<tr>
<th>Moderator</th>
<th>Predictor</th>
<th>Dependent variable</th>
<th>Moderating coefficients</th>
<th>T statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social integration</td>
<td>H3c. Knowledge transfer</td>
<td>Knowledge Institutionalization</td>
<td>0.37***</td>
<td>2.75</td>
</tr>
<tr>
<td>Environmental</td>
<td>H4a. Knowledge identification</td>
<td>Competitive advantage</td>
<td>0.15</td>
<td>0.79</td>
</tr>
<tr>
<td>dynamics</td>
<td>H4b. Knowledge protection</td>
<td>Competitive advantage</td>
<td>-0.28*</td>
<td>1.56</td>
</tr>
</tbody>
</table>

*Significant at 10% level. **Significant at 5% level. ***Significant at 1% level.

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Hypothesis 4a, but the effect is not significant (path coefficient = 0.15, \( p > 0.1 \)). However, the same moderator environmental dynamics has a negative significant effect on the knowledge protection → competitive advantage link (path coefficient = −0.28, \( p < 0.1 \)). It thus appears that the dynamism of an organization’s environment plays a major role only in affecting the level of influence that knowledge protection has on a firm’s performance. Hence, Hypothesis 4a is not supported while Hypothesis 4b is.

To better understand the unexpected outcome of H4a’s result, we conducted additional post hoc analysis by testing the effect on all three components of competitive advantage. Our rationale was that earlier we found that the path knowledge identification → competitive advantage was not significant but knowledge identification → innovativeness was. However, our analysis found no support for the moderating effects of environmental dynamics on the paths knowledge identification → innovativeness, knowledge identification → strategic flexibility, and knowledge identification → performance.

### Discussions

In this paper we have studied how the effects of network closure on the focal organizations’ competitive advantage are mediated by knowledge processes. The inclusion of internal social integration mechanisms and environmental dynamics further enrich the model. Our empirical results from the Chinese petrochemical industry reveal several important findings, but they should be interpreted with care due to the small sample size and the low response rate we received despite our best effort in data collection.

The apparent contradictory effects of network closure on competitive advantage observed in the existing literature (e.g. see Burt (1992), Coleman (1988), Uzzi (1997), Ahuja (2000), Brass et al. (2004)) were related to closure’s negative effect on knowledge identification and positive effect on knowledge protection. Since knowledge identification is positively related to innovativeness, an important element of competitive advantage, and knowledge protection is positively related to competitive advantage, the result is an offsetting of the effects of network closure.

Further analysis has revealed that knowledge transfer does not mediate the relationship between network closure and competitive advantage. This result is different than that of previous studies that emphasize the benefits of the ease of knowledge transfer in a closed network. This contradiction is explained by our study which shows that, although knowledge transfer does not directly impact an organization’s competitive advantage, the conversion of transferred knowledge into firm-level institutionalized knowledge aided by strong social integration mechanisms is a factor in the enhancement of competitive advantage. This study therefore uncovers the missing link between knowledge transfer and knowledge institutionalization.

The outcome of H4b suggests that, in industry sectors with low environmental dynamism, it is important for firms to protect their knowledge in order to gain and maintain their competitive advantage. In this type of environment, the positive effect of network closure on knowledge protection contributes positively to competitive advantage. Hence, we can conclude that organizations in industries characterized by a stable technological regime favor a closed network.

Some studies provide empirical support for the above argument. In a study comparing Toyota and Silicon Valley, Ahmadijian (2004) found that, in the relatively stable environment of the automotive industry, the close relationship between Toyota and its partners was a key success factor for its growth. In contrast, a sparse network fits Silicon Valley’s dynamic environment and contributes to its growth.

<table>
<thead>
<tr>
<th>Degree of social integration capabilities</th>
<th>Knowledge transfer → knowledge institutionalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Beta</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Social integration ≤ −0.5</td>
<td>18</td>
</tr>
<tr>
<td>−0.5 &lt; social integration &lt; +0.5</td>
<td>33</td>
</tr>
<tr>
<td>Social integration ≥ +0.5</td>
<td>27</td>
</tr>
</tbody>
</table>

regional growth. Similarly, Baum et al. (2000) discovered a positive relationship between a sparse network and innovativeness in Canadian biotechnology startups that operate in a dynamic industry, while in the relatively stable chemical industry Ahuja (2000) found it is beneficial to have network closure.

**Implications and directions for future research**

Our study has some important implications for research and practice. In terms of implications for research, by opening the black box between network closure and competitive advantage, the current study was able to examine the mediating effects of knowledge processes in detail. This fine-grained analysis revealed the dual effects of network closure on knowledge identification and protection, and thus sheds light on the long-standing debate between network closure (Coleman, 1988) and the structure holes theory (Burt, 1992). That is, network closure affects an organization’s competitive advantage positively because it offers better knowledge protection. However, network closure also affects an organization’s competitive advantage negatively because it constrains the knowledge identification of an organization. Our study demonstrates that scholarly research linking the micro level perspective (e.g., knowledge management practices) to social network research may produce new insights with strong managerial implications.

Our findings have several practical implications, particularly for guiding managers to make decisions on the location of their organizations in appropriate network settings that will allow them to exploit greater benefits from a given network structure.

Firstly, the finding that the relationship between network structure and competitive advantage is not mediated only by knowledge identification and protection but also moderated by environment dynamics reveals a set of factors that may inform managers on the design of their firm’s network structures. We assume that organizations have some level of control in the formation of technological relationships such that organizations adept at developing their network in a manner consistent with the requirements of environment dynamism can extract more value from the network compared to a less able organization. In other words, organizations could be more efficient in transforming social networks into social capital (Burt, 2000).

Moreover, as an organization’s internal social integration mechanisms are crucial in transforming transferred knowledge into institutionalized knowledge, managers should balance their efforts between building inter-organization linkages for technology access and lowering internal learning barriers to institutionalize the transferred-in knowledge. We argue that internal capabilities and external knowledge are complements to, not substitutes for, each other (Caloghirou et al., 2004; Schroeder et al., 2002; Hansen and Oetinger, 2001). All things being equal, we expect that the higher the level of social integration mechanisms, the more an organization will benefit from a closed network.

Based on these results and the literature review, we propose a matrix (see Fig. 2) which indicates the preferred choice of network structure according to the degree of environmental dynamics and the level of social integration in the organization. When the industry is characterized by stable technological development, organizations with relatively high social integration mechanisms should consider a closed network structure both to protect their core technologies and to learn from their partners. The dilemma between knowledge identification and protection will be low under such a network setting.

In addition, the drawbacks of such a structure on knowledge identification will not be severe due to competitive advantages the organizations enjoyed under the given stable environment. In other words, the benefits of network closure will mainly be generated by tight knowledge protection. It is further inferred that when the strategic flexibility dimension precedes the innovativeness dimension the merits of knowledge protection will be decreased to a significant degree and organizations might choose to have sparser networks.

In contrast, when the industry is characterized by dynamic technological development, organizations with relatively low social integration mechanisms should consider a sparse network structure to harvest the benefits of knowledge identification that facilitate flexibility in strategic decision making. In this case, knowledge protection will not be as important as in stable environments.
for enhancing the competitive advantage of the organization. Furthermore, organizations that have low social integration mechanisms and operate in such an environment barely have enough time to transform any transferred knowledge into institutionalized knowledge and, hence, might not be able to realize the potential benefits of network closure. However, organizations with high social integration mechanisms may choose to tighten their network structure in order to learn more efficiently from their alter partners as long as the institutionalization process can be done in a timely manner. Moreover, it is inferred that organizations might further tighten their network structure when the innovativeness dimension precedes strategic flexibility and, hence, highlights the merits of knowledge protection.

In summary, a balanced network structure that allows the organization to both identify new knowledge trends and to promote knowledge protection – combined with balanced managerial efforts that advocate both external linkage and internal sharing in facilitating knowledge transfer and institutionalizing knowledge – could help organizations extract maximum competitive advantages from inter-organizational learning.

The findings of this study should be placed in the proper perspective by keeping the following limitations in mind. Firstly, although this study has shown the importance of environmental dynamics, it has excluded other aspects of environment such as competitive intensity and demand uncertainty. Secondly, the exclusion of other network characteristics (e.g. network centrality) means our findings need to be interpreted with care as the effect of network closure may be influenced by other network characteristics. Thirdly, the sample size, low response rate and single source of respondents mean the results need to be further verified by reference to a larger sample size and responses from different sources (e.g. company archives) to eliminate any common method bias. Some of the variables were measured with only two items which may exhibit low reliability. Fourthly, the ego network design and name generator methods may have resulted in large organizations excluding some partners in their network. Finally, this is a cross-sectional study and can only reveal correlations; causation effects will require a longitudinal study with time lags.

These limitations suggest several possible directions for future research. Firstly, future studies should consider a more thorough examination of other aspects of environment dynamics (e.g. competitive intensity and demand uncertainty, cf. Jaworski and Kohli, 1993; Grewal and Tansuhaj, 2001), especially in settings where technology plays a less important role in achieving competitive advantage.

A second possible direction is to examine how other parameters of network structure such as network centrality or brokerage affect the influence of knowledge processes on competitive advantage. The network data can also be separated into formal relationships (at the organization level) and informal networks (at the employee level). Such segregation could reveal further information

Fig. 2. Matching network structures with environmental dynamics and organizational integration.
with regard to understanding different network types and their relative roles in inter-organizational learning.

A third possible area is to study the subject using patent data at an organization level over time, thereby extending the work of Fleming et al. (2007) which was done on an individual level. By combining the patent data over time with the knowledge management activities in the organization, it is possible to eliminate the common method bias completely.

Conclusion

We have taken a holistic view in studying the effects of network closure on an organization’s competitive advantage in the Chinese petrochemical industry. Network closure affects competitive advantage by exerting a negative effect on knowledge identification and a positive effect on knowledge protection. As a result, the effects may sometimes cancel each other out. Studies in different settings may show network closure to be either a positive or a negative characteristic, depending on whether knowledge identification or knowledge protection is more important. We have also found that even though a closed network facilitates knowledge transfer, the transferred knowledge must be institutionalized in the receiving organization before it can contribute to competitive advantage. The existence of strong social integration mechanisms within the organization is necessary for a successful institutionalization effort.

Moreover, we found that the advantage of network closure is contingent upon environmental dynamism. A sparse network facilitates knowledge identification which helps an organization increase the strategic flexibility that is necessary to maintain the ability to respond to fast unexpected changes. Conversely, a closed network facilitates the knowledge transfer and protection that are necessary for organizations to innovate and extract value from their innovations in a stable environment.

Uncited references


Appendix A. Questionnaire design and measurement items

We adopted the ego-centric approach in the questionnaire design. Following standard procedures of name generators and name interpreters (Marsden, 1990; Burt, 1992), in the questionnaire we asked:

- Regarding your last collaborative project and/or ongoing project with technical partners, please list 3–4 firm names that you have the most intensive technical knowledge exchange.
- Please recall your most important technical partner relationships before this year, please list 3–4 names of firms that have played key roles in advancing your firm’s technology.
- Generally speaking, please list 3–4 names of firms that you have intense informal technical discussion/communication with.

After respondents listed all names of their technical partners, they were asked to sort those names so that there would not be any repeated names in the final list. They were also given a chance to add to the final list important technical partners that were left out in the previous name generator stage.

For the last step respondents were required to circle out all close relationships as well as all arm’s length relationships among their technological partners. As an example, say one firm Alpha had nominated five firms, A1, A2, A3, A4, and A5 which it has a close relationship. Alpha then completed the network information as shown below:

From the figure we can read that Alpha rated firm A2 and A3 collaborate closely with each other, so for A1 and A4, A2 and A5, and A4 and A5. In this case the total pairs of possible close relationships are 5*4/2 = 10. The network closure for this firm is given by 4 (pairs of close relationship) divided by 10 (pairs of possible close relationship), i.e., 0.4.

A.1. Construct measurements

Network closure (Rowley et al., 2000)

The ratio between the sum of the existing ties in the ego network (other than those involving the focal organization) and the total possible number of ties among its partners if each partner were tied to every other partner.

 Organization size

- Number of employees (Log).
- R&D investment
- Actual investment (Log).

Knowledge identification (Rowley et al., 2000)

- We can detect the latest technical trends within our industry.
- We can track the latest technical trends in relevant industries.
- When there are radical innovations/major breakthroughs within the industry, we are able to get to know them and estimate their impacts on our business.

Knowledge transfer (Szulanski, 1996)

- Our partners are willing to share their technical knowledge.
- It is not difficult for partner firms to explain their technical knowledge to us.
- Generally speaking, our knowledge source is reliable and usable.
- We encourage our employees/teams to learn technical knowledge from our partners.

Knowledge institutionalization (Szulanski, 1996)

- We can apply newly acquired technical knowledge to our product lines.
- We have successfully institutionalized partners’ technical knowledge, so that key employees’ turnover would not affect our performance.

Knowledge protection (Kale et al., 2000)

- Our company has been able to protect its core capabilities or skills from the partner.

• Our company has been successful in protecting its crown jewels from being appropriated by the partner.

Social integration mechanisms (Zahra and George, 2002)

• Our technical knowledge gatekeepers are willing to share acquired partner knowledge to other employees/departments.
• Our technical knowledge gatekeepers can effectively share acquired knowledge to other employees/departments.
• We have policies to motivate internal technical knowledge sharing.

Environmental dynamics (Jaworski and Kohli, 1993)

• In general, our company’s main products have a rather short life-cycle (e.g. 3–6 months).
• The technology in our industry is changing rapidly.
• It is very difficult to forecast where the technology in our industry will be in the future.
• Our R&D activities cover a wide range of relevant areas.*

Innovativeness ( Zaheer and Bell, 2005)

• We have more innovative products/processes than our competitors.
• We tend to lead the industry in introducing new products/new processes and adopting new technologies.

Strategic flexibility ( Grewal and Tansuhaj, 2001)

• We are able to derive benefits from diversity (e.g. diversified customer needs and partners) in the environment.*
• We are able to derive benefits from variability (e.g. fast new product introduction rate) in the environment.
• We are able to manage macro-environmental risks (i.e., political, economic, and financial risks).

Performance ( Worren et al., 2002)

• Over the past year, our financial performance has been outstanding.
• Over the past year, our financial performance has exceeds our competitors.
• Over the last year, our sales growth has exceeded our competitors.*

*Deleted.

References


