Trailing organizational knowledge paths through social network lens: integrating the multiple industry cases

Young-Gul Kim, Yong Sauk Hau, Seulki Song and Ghi-Hoon Ghim

Young-Gul Kim is based at KAIST Business School, Seoul, Republic of Korea. Yong Sauk Hau is based at the School of Business, Yeungnam University, Gyeongsan, Republic of Korea. Seulki Song and Ghi-Hoon Ghim are based at CYRAM, Seoul, Republic of Korea.

Abstract

Purpose – *This study aims at analyzing the features of knowledge flow and the role-specific nodes in knowledge networks among individuals and business units of six organizations in different industries, and suggesting prescriptions to prevent the organizational knowledge sclerosis.*

Design/methodology/approach – *This research conducts multiple case studies on the organizational knowledge paths of six companies in the multiple industries through social network analysis (SNA) tool developed by the authors of this paper.*

Findings – *This study provides four major findings which shed a new light on how to comprehend the features of knowledge flow and the role-specific nodes in knowledge networks in organizations: the within-business unit knowledge flows are more dominant over the inter-business units knowledge flow; the downward knowledge flows are dominant over the horizontal and upward knowledge flows in the management levels; distributions of knowledge owners and providers are like L-shape and the gap between knowledge owing and providing expands as the management levels go up; and the top 20 percent people in an organization dominate over a large portion of the knowledge brokerage activities.*

Research limitations/implications – *Cultural difference issue might arise because data collection was limited to Korean organizations. Therefore, the findings from this study needs to be cautiously interpreted considering the cultural difference/deeper understanding of the organizational knowledge paths through social network lens can make it possible for more context-specific KM strategies (e.g. suitable for a specific functional unit, management level, or industry type) to be identified and implemented.*

Practical implications – *Managers can have a solid grasp about knowledge flows and knowledge node roles in their organization through social network analysis in order to facilitate the knowledge transfer and eliminate the knowledge link lapse in organizations.*

Originality/value – *This study could be a stepping stone for further empirical research since it expanded the level of organizational knowledge network analysis from individual and team to inter-unit and inter-management level through the block modeling analysis of knowledge network.*

Keywords *Social network analysis, Knowledge flow, Knowledge map, Knowledge brokerage, Knowledge network, Knowledge node*

Paper type *Research paper*

1. Introduction

Comprehending knowledge networks is of great importance to organizations trying to create and sustain their competitive advantage through knowledge management (KM) (Phelps *et al.*, 2012). Without understanding how and where knowledge flows or stops among organizational members and across organizational units, it is difficult for managers to effectively support knowledge sharing and creation among employees or sharing and transfer of cross-organizational knowledge in their companies. Traditionally, most managers presuppose that knowledge and information flows mainly along the formal organizational hierarchy as evidenced by the reporting lines of their organizational charts. However, several studies show that informal social networks among organizational members comprise a more potent source of organizational knowledge (especially tacit knowledge) and collaboration

Received 24 June 2013
Revised 11 October 2013
28 October 2013
Accepted 29 October 2013

(Chung and Jackson, 2013; Schweer *et al.*, 2012; Whelan *et al.*, 2011). And social network analysis (SNA) enables managers to discover where and how knowledge flows or stops within organizations (Cross *et al.*, 2010). Accordingly, there have been various studies about knowledge network based on SNA but most of them seem to provide few explanations about the following questions concerning knowledge network in practice, which this study aims to answer:

1. How can we effectively identify the knowledge flow paths within organizations (e.g. how to recognize the knowledge flow bottlenecks between management levels or among business units)?
2. How can we effectively detect the characteristics of the role-specific node in the organizational knowledge network (e.g. how to identify the features of the role-specific node such as knowledge owner, knowledge provider, or knowledge broker)?

More specifically, this research aims at suggesting a new way of understanding organizational knowledge networks in terms of both the knowledge flow and the knowledge node by applying SNA to six different organizations in six different industries in practice.

This paper is composed of six sections. The next section deals with literature review, the third explains the research methodology for this study, the fourth reports the findings from the authors' multiple case studies, and the fifth discusses the findings, and the last section presents the conclusion from this study.

2. Literature review

Knowledge network is defined as ''a set of nodes – individuals or higher level collectives that serve as heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge – interconnected by social relationships that enable and constrain nodes' efforts to acquire, transfer, and create knowledge (Phelps *et al.*, 2012, p. 1117)''. This definition points out that knowledge network has no room for its existence without social relationships because knowledge network itself is based on the interconnections by social relationships within an organization. SNA is very useful in making an effective analysis about the interconnections by social relationships (Cyram, 2008), which makes SNA indispensable to knowledge network research. The major findings, unit of analysis, and industrial contexts of the SNA-based knowledge network research are summarized in Table I. However, they seems to be limited in the following three aspects:

1. The previous studies have been narrow at their research contexts and applications. The contexts of previous studies have been one or just a few industries such as the high-tech industries and they have been often focused on IT applications rather than common business applications. To increase the generalizability of the findings from prior research, a more diverse set of industries and applications needs to be addressed.
2. Few previous studies have looked into both the knowledge flow and the role-specific node aspects of the organizational knowledge networks at the same time.

"Without understanding how and where knowledge flows or stops among organizational members and across organizational units, it is difficult for managers to effectively support knowledge sharing and creation among employees or sharing and transfer of cross-organizational knowledge in their companies."

Table I Prior knowledge network research

References	*Method*	*Major finding*	*Unit of analysis/context (industry)*
Schweer *et al.* (2012)	Case study with survey and SNA	By applying SNA to analyzing employees' talent networks, manager can understand and promote more effective collaboration in organizations	Individual/no specified industries to which the research subjects in SNA belong in the article
Whelan *et al.* (2011)	Case study with survey and SNA	Through SNA, the link between ''idea scouts'' and ''idea connectors'' in organizations can be effectively identified and it is necessary to make them connected in order to make more successful outcomes from open innovation	Individual/the high-tech engineering, the information and communication technology, the energy, the management consulting, and the financial services industries
Chung and Jackson (2013)	Empirical study with social network measure	Teams' external work network positively influences their performance and their internal trust network has an inverted U-relationship with it. Task routineness is a significant moderator for these relationships	Team/biology and chemistry research teams in a university
Cross *et al.* (2010)	Case study with survey and SNA	SNA helps to visualize the collaborative networks in a company and design them effectively and efficiently to optimize the inflow and outflow of good ideas in it	Individual, team, department/the utility, the petrochemical, the pharmaceutical, the professional services, and the high-tech industries
Cross *et al.* (2009)	Case study with survey and SNA	SNA enables mangers to see how their decisions are biased by the informal networks in their company	Individual, team/the pharmaceutical industry
Singh *et al.* (2010)	Empirical study with a network field experiment	Peripheral status in the social network and homophily aggravate the inefficiency of employees' knowledge searching	Individual/the management consulting industry
He *et al.* (2009)	Case study with empirical analysis	Social relationship makes more favorable attitudes toward knowledge sharing, and promotes the usage of knowledge management system	Individual/the chemical industry
Chow and Chan (2008)	Empirical study	Social network and shared norms positively influences the intention to share knowledge, mediated by attitudes toward knowledge sharing and subjective norms about it	Individual/multiple industries
Cross *et al.* (2007)	Case study with survey and SNA	SNA is a very useful to detecting information and knowledge flow in a firm and increasing collaboration and innovation in the firm	Individual, group, business unit/the professional service industry
Allen *et al.* (2007)	Case study with survey and SNA	There are significant differences between formal and informal knowledge network of the R&D function within an organization Better understanding of informal knowledge network in R&D is important to the success in detecting, exploiting and transferring new ideas and knowledge across the function	Individual, group, business unit/The chemical industry
Chiu *et al.* (2006)	Empirical study	Social interaction ties positively affect the quality of knowledge sharing in the virtual community	Individual/the IT industry

(*Continued*)

Table I

References	*Method*	*Major finding*	*Unit of analysis/context (industry)*
Wasko and Faraj (2005)	Empirical study with social network measure	Centrality is positively associated with both the usefulness and the quantity of knowledge contribution in the electronic networks of practice	Individual/the legal industry
Levin and Cross (2004)	Empirical study with social network measure	Strong ties have a positive effect on receipt of useful knowledge, mediated by competence and benevolence-based trust	Individual/the pharmaceutical, the banking, and the oil and gas industries
Simon and Galunic (2004)	Empirical study with social network measure	The heterogeneity of knowledge in a manager's social network has positive influences on the manager's both overall and innovation performances	Individual/the telecommunication industry
Reagans and McEvily (2003)	Empirical study with social network measure	Both social cohesion and network range have positive effects on easing knowledge transfer, over and above the impact for the strength of relationship between two persons	Individual/the technical R&D consulting service industry
Spencer (2003)	Longitudinal quantitative case study with social network measure	The structural features such as density, centrality and brokerage in the knowledge network have significant effects on the competitiveness of companies and industries	Firm, industry/the flat panel display industry
Hansen (2002)	Empirical study with social network measure	The lengths of the inter-unit network paths of new product development project teams have significant effects on their projects completion time and the knowledge which they receive from other business units	Team, business unit/the electronics industry
Cross *et al.* (2002)	Case study with SNA	Employees informal networks play an important role in organizations, and managers need to make efforts to understand and build them effectively in their company	Individual, business unit/no specified industries to which the research subjects in SNA belong except the government sector and the banking, a technology, and the pharmaceutical industries in the article
Tsai (2002)	Empirical study with social network measure	Centralization (formal hierarchical structure) negatively influences intra-organizational-unit knowledge sharing whereas social interaction (informal lateral relation) positively influences it among business units which have competitive relationship with each other for market share	Business unit/a company with multi-business units which have diversified into various industries, starting from the petrochemical industry

3. The prior research has paid little attention to important knowledge network characteristics such as knowledge flow patterns across intra/inter business units or management levels and the role-specific knowledge node patterns.

To overcome the limitations of the prior studies, the authors report on the results of multiple case studies on six organizations from six different industries. First, the authors identify the knowledge flow paths among individuals and business units by using the SNA tool, NetMiner 3 developed by the authors of this article, to come up with a knowledge flow network of the participating organizations. Second, the authors examine the general structure and features of each organization's knowledge flow network as well as the role-specific node features (knowledge owner, knowledge provider, and knowledge broker). Third, the authors analyze each organization's knowledge flow patterns according to its intra/inter business units and five management levels, diagnose the general flow patterns, and suggest prescriptions to remove bottlenecks in knowledge network and facilitate organizational knowledge flow.

3. Research methodology

In order to explore the existence and patterns of various organizational knowledge paths in different industry settings, the authors conducted a comparative case study. Among the 50 + member firms of the university-affiliated KM consortium in Korea, six organizations from six industries (Alpha: oil refinery, Beta: mobile and tele-communication, Gamma: shipbuilding, Delta: investment and securities, Epsilon: hospital, Zeta: food manufacturing) participated. From the six organizations, a total of 2,208 business people at five management levels (employee, assistant manager, manager, associate general manager, general manager) initially agreed to participate in the study, ranging from 115 (Delta) to 456 (Alpha) participants. Among those, 1,794 (response rate of 81.3 percent) finally answered the network survey from August 13, 2009 to August 13, 2010. The authors first conducted the within-case analysis of the six firms, followed by the cross-case analysis for comparison and synthesis of commonly observed knowledge flow network patterns.

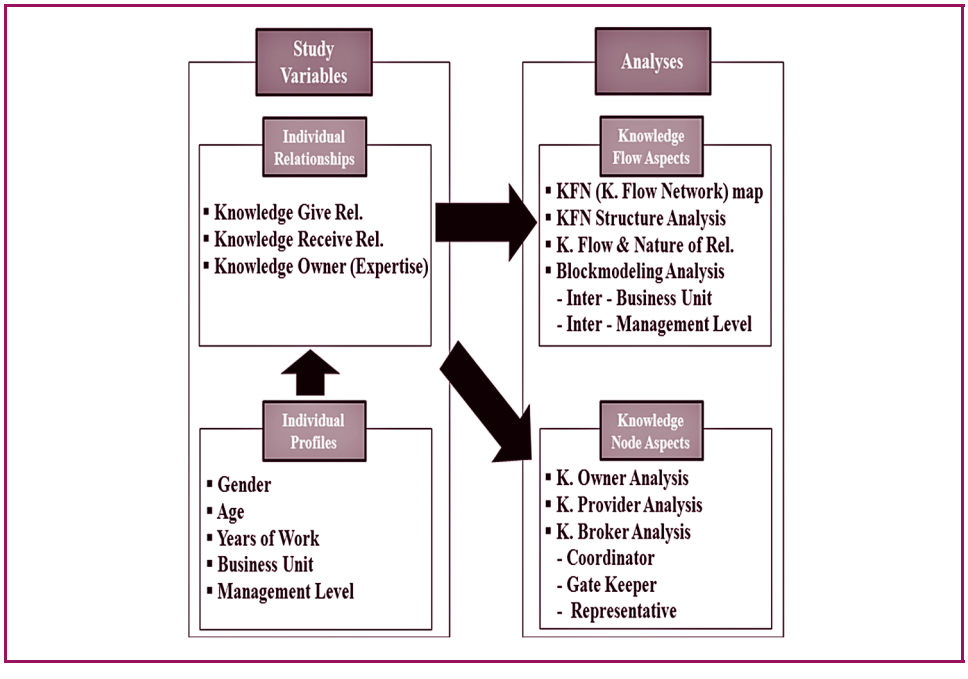
Case data was collected through a ''multiple name generator'' type questionnaire, which is one of the widely used SNA methods (Marsden, 2005; Burt, 1984). This survey method directly measures the knowledge owner (expertise) and knowledge flow (provide and receive) relationships among organizational members where each member is expected to nominate other members in such relationships. This method is deemed appropriate in diagnosing a social network among individuals who belong to the same organization and maintain continuous relationships with one another (Marsden, 2005). The actual survey was conducted online and consisted of two network questions about the knowledge owner (expertise) and the knowledge flow relationships. Based on the respondents' answers to these questions, each organization's knowledge flow network map was constructed and the individuals' network roles/locations (knowledge owner, provider, and broker) were derived for further analysis. Figure 1 shows the overview of the variables used and the analyses conducted in this study.

4. Findings from multiple case studies

4.1 Knowledge flow paths within Alpha

The authors have chosen Alpha as the representative case among the six participating organizations based on the two criterion: the response rates of the online network survey and

Figure 1 Overview of the study variables and analyses



the closeness to the average organization-wide measurements on the five social network structural indices (average geodesic distance, giant component percentage, clustering coefficient, network density and degree of concentration) as shown in the Tables II and III. In the response rates of the online network survey from the six organizations, the highest three were Alpha (100.0 percent), Epsilon (97.3 percent), and Delta (90.6 percent). In Alpha, out of the 456 initial participants, 456 completed the online network survey. For the two network questions, they nominated an average of 3.83 persons for knowledge owner (expertise) and 3.35 persons for knowledge flow relationships, respectively. Among the highest three organizations in the response rates, Alpha came closer to the respective means of average geodesic distance, giant component percentage, and network density in the five social network structural indices of the six organizations as compared in the Table III.

Figure 2 shows the Alpha's organizational knowledge flow network map. It is constructed based on the knowledge receive relationship question (''please, enter the names of your colleagues (up to seven people) who provided you with useful knowledge for your work in the past six months''). In the map, circles are people who participated in the survey and triangles are people who initially were listed as participants but did not participate (still, they could be nominated by others as knowledge providers). The five symbol colors represent the five business units of the firm and the size of a symbol increases in proportion to a person's management level. People on the periphery of the map without any linked arrows (19, about 4 percent) are the ''loners'' who do not have anyone to exchange knowledge with. Further inside from the ''loner'' group are isolated small clusters (called components) of people (0 percent since Alpha's loners do not form any component) who belong to some local components but are disconnected from the main knowledge flow network of their firm.

Table II Alpha's structural indices of knowledge flow network

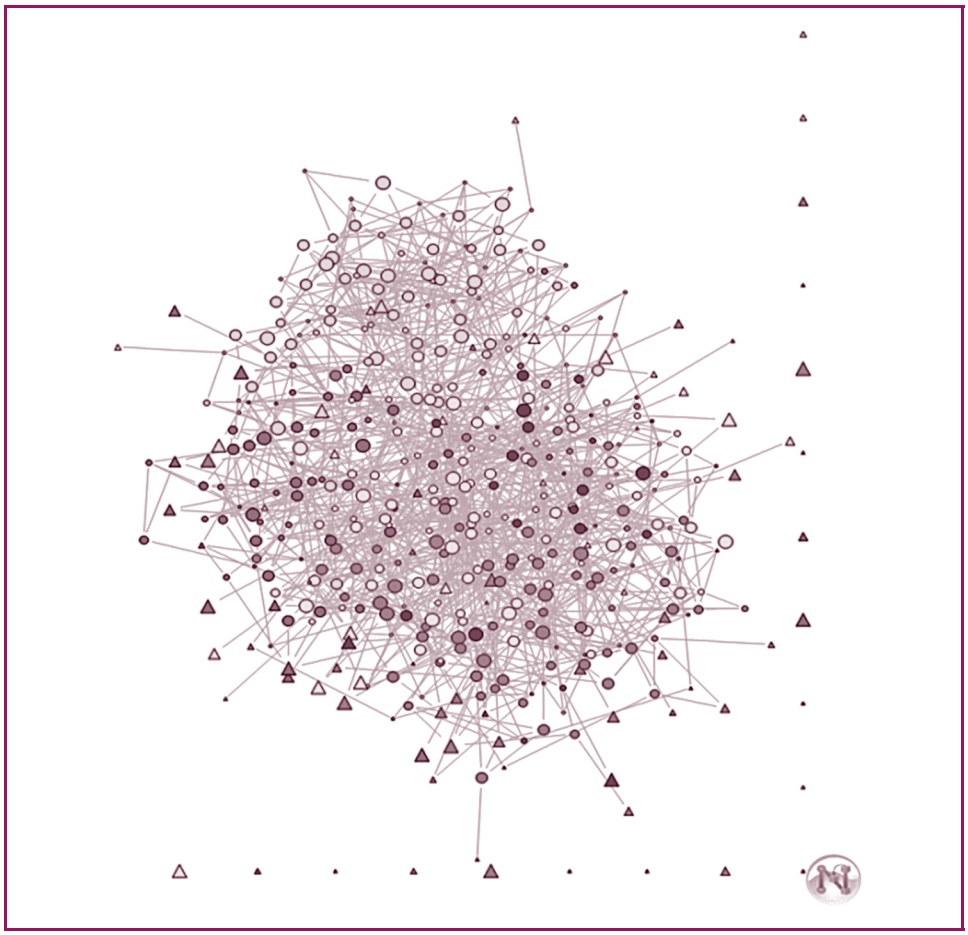
Structural index	*Definitions*	*Alpha*
Average geodesic distance (Newman, 2003)	The mean shortest path-length between any pair of nodes in a network	5.43
Giant component percentage (Newman, 2003)	The percentage of the largest, main connected subset in a network	95.8%
Clustering coefficient (Watts and Strogatz, 1998; Wasserman and Faust, 1994)	How close the vertex and its neighbors are from being a clique (complete graph). The likelihood that neighbor associates connected to a node (common person) are also associates themselves (connected with one another)	0.15
Network density (Wasserman and Faust, 1994)	How densely or sparsely a network is organized, calculated by the ratio of actual existing links among every connectable link of a network	0.01
Degree of concentration (Huang *et al.*, 2007)	Whether link in a network is equally spread out through the network or owned by a small number of nodes, which is calculated by the Gini coefficient	0.282

Table III The summarized results of analyses on knowledge flow aspects in six case companies

	KFN structure analysis					*BMA at BU level*		*BMA at MGT level*		
Company	*AGD*	*GCP (%)*	*CC*	*ND*	*DC*	*Within-unit (%)*	*Inter-unit (%)*	*Downward (%)*	*Horizontal (%)*	*Upward (%)*
Alpha	5.43	95.8	0.15	0.01	0.282	65	35	41	30	28
Beta	5.92	81.6	0.23	0.01	0.277	95	5	35	29	37
Gamma	6.77	94.4	0.26	0.01	0.593	94	6	61	21	19
Delta	4.31	96.1	0.25	0.03	0.824	61	39	36	46	18
Epsilon	6.79	98.4	0.41	0.01	0.572	90	10	28	65	8
Zeta	5.05	96.4	0.24	0.01	0.451	67	33	44	31	26
Average	5.71	93.8	0.26	0.01	0.500	79	21	41	37	23

Notes: *KFN: Knowledge flow network; BMA: Blockmodeling analysis; BU: Business unit; MGT: Management; AGD: Average geodesic distance; GCP: Giant component percentage; CC: Clustering coefficient; ND: Network density; DC: Degree of concentration

Figure 2 Alpha's organizational knowledge flow network map



Judging from the clustering of nodes of the same color, knowledge flows between people in the same business unit seem to be more dominant than the inter-unit knowledge flows. Centrally-located large symbols suggest that, in Alpha, high-level managers are more actively involved in the organizational knowledge transfer.

In order to detect the structural features from Alpha's organizational knowledge flow network, the authors calculated the five social network indices by using NetMiner 3 (Cyram, 2008):

- average geodesic distance;
- giant component percentage;
- clustering coefficient;
- network density; and
- degree of concentration.

The definitions and Alpha's values of these indices with quoted references are described in Table II.

First, average geodesic distance is the mean number of links any two members of the network have to traverse to be connected (Newman, 2003). The shorter the distance, the faster and easier the knowledge transfer. Alpha's average geodesic distance is 5.43, which suggests that an employee in Alpha needs to go through more than five people before meeting the target person. Second, a giant component of an organization is the largest, main connected subset of any organization's knowledge flow network (Newman, 2003). It suggests that the higher the giant component percentage is, the lower the portion of the

> **"Managers should have a solid grasp about knowledge flows and knowledge node roles in their organization in order to facilitate the knowledge transfer and eliminate the knowledge link lapse among organizational members."**

isolated ''island'' or ''loner'' nodes in an organization will be. Table II shows that about 4 percent of the people are not connected to Alpha's main knowledge cluster, subjecting themselves at ''knowledge disadvantage''. Third, clustering coefficient measures the probability that two people connected to a common person are also connected with each other (Wasserman and Faust, 1994). High clustering coefficient signals that local nodes (within a department or team) are tightly connected with each another. Fourth, network density measures how densely or sparsely a network is organized, calculated by the ratio of actual existing links among every connectable link of the network, ranging from zero to one (Wasserman and Faust, 1994). Lastly, degree of concentration reveals whether provision of knowledge in an organization is spread out through the organization or most knowledge is provided by a small number of experts (Huang *et al.*, 2007). Zero corresponds to perfect equality (everyone providing exactly the same knowledge) and one corresponds to perfect inequality (where one person provides all the knowledge in an organization, while everyone else does not). The values of clustering coefficient, network density, and degree of concentration of Alpha are 0.15, 0.01, and 0.282, respectively. The detailed discussions including comparisons among the six companies will be introduced in the cross-case comparisons section.

Blockmodeling analysis: while this study examines knowledge flow paths between individuals based on individual-level data, when we aggregate these data to the business unit level or management level, we can analyze the inter-unit or inter-management level analysis, called blockmodeling analysis (Doreian *et al.*, 2005; Wasserman and Faust, 1994). According to the blockmodeling analysis on unit-level knowledge flows in Alpha, within-unit knowledge flows are dominant over inter-unit knowledge flows. However, the ranges among the within-unit knowledge flows are diverse from 12.79 (BU4) to 31.77 (BU3) as are those among inter-unit knowledge flows from −11.51 (BU4 → BU3) to 0.34 (BU2 → BU4). Additionally, blockmodeling analysis at the management level in Alpha shows that the within-level (horizontal) and the inter-level (downward and upward) knowledge flows are quite diverse depending on management levels. More specifically, the downward knowledge flows are dominant over the horizontal and the upward knowledge flows. Since top-down knowledge flows between management levels do not always imply the ideal type of knowledge sharing in organizations (Hansen, 1999), managers in Alpha may need to diversify the directions of their knowledge flows based on these blockmodeling results.

4.2 Roles of knowledge node at Alpha

In a typical organization's knowledge flow network, knowledge flows from a source node (knowledge provider) to a recipient node (knowledge receiver) (Yang and Kim, 2007). To promote active knowledge transfer within organizations, it is critical to motivate knowledge owners to become active knowledge providers. Likewise, knowledge receivers should be encouraged to play the role of knowledge brokers to facilitate the knowledge spread to the rest of the organization. Thus, in this section, the authors analyze the roles of knowledge owner, knowledge provider, and knowledge broker in terms of their distribution patterns.

Knowledge owners are people who possess expertise in certain business fields or tasks (Huysman and de Wit, 2002). They are identified in this study through their colleagues' nominations. Expertise points indicate the frequency of their nomination as internal experts.

As shown in Figure 3, Alpha's expertise points have an ''L-shaped'' distribution, wherein only a small number of people have high points while more than half of the population has 0, 1 or 2 point. While the average expertise point increases as the management level goes up, it is interesting to note that they peak at the associate general manager level, and not at the general manager level. It might be interpreted in two ways. First, Alpha's general managers tend to focus on managing their subordinates and, over time, are likely to become insulated from actual functional tasks. Or, since general managers, in Alpha, are less available and busy most of the time, their expertise may not be easily understood or accessible to their subordinates.

Knowledge providers are people who help other people through the use of their knowledge, identified by other people's nominations through the ''knowledge receive relationship question''. In Alpha, knowledge providers have very similar distribution patterns to those of knowledge owners (e.g. L-shape, peaking at the associate general manager level, etc.). Here, a more interesting observation is made regarding the gap between the expertise and knowledge provision points at the respective management levels. At the employee and assistant manager levels, as seen in Figure 4, knowledge provision points are higher than expertise points (that is, while they do not have much knowledge, they are willing to help others with their knowledge). However, at the manager level, expertise points become

Figure 3 The knowledge owner distribution in Alpha

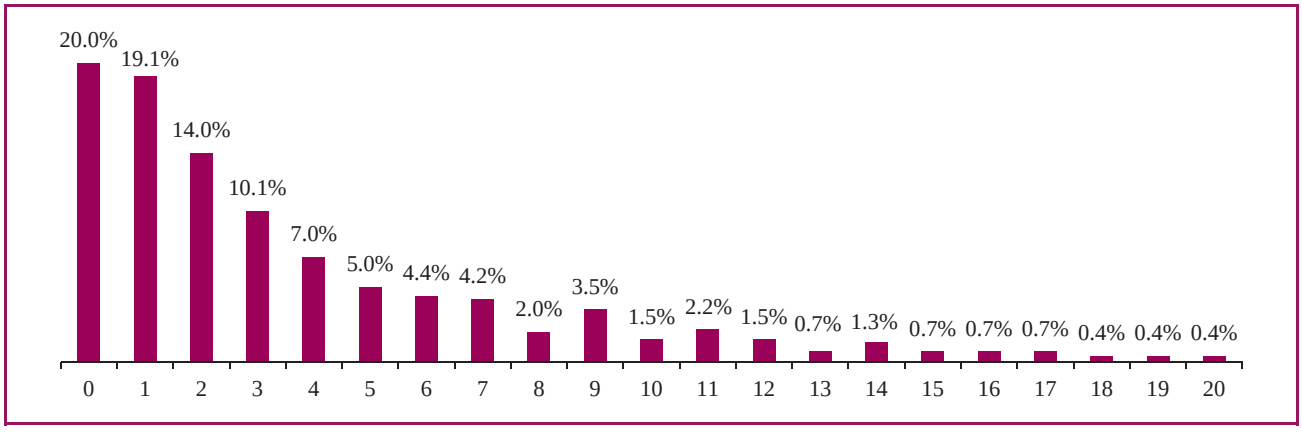
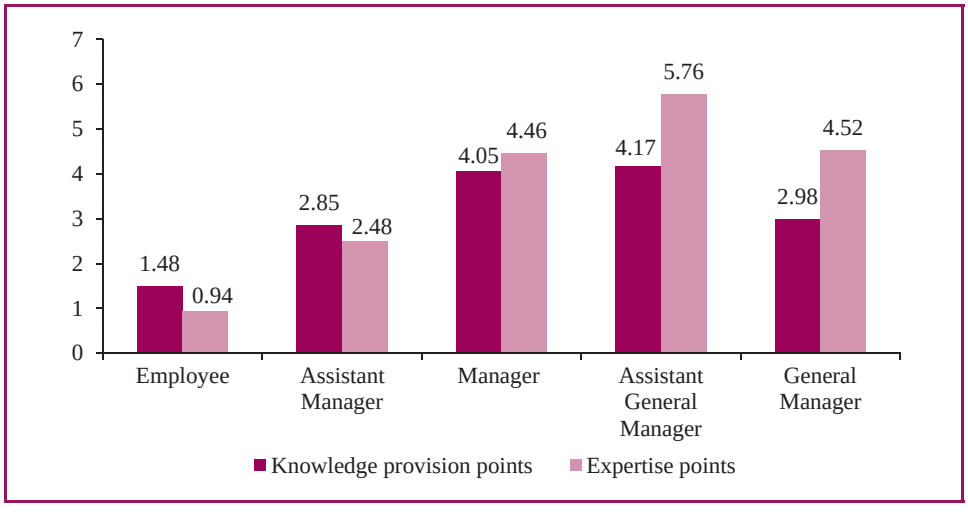


Figure 4 The comparison between the expertise and the provision points along with five different management levels in Alpha



slightly higher than the knowledge provision points and, at the associate general manager and general manager levels, such gap significantly widens, signaling the need to motivate the higher-level managers to contribute their knowledge more actively.

Knowledge brokers are people who play the role of intermediary between knowledge owners/providers and those in need of knowledge. The fact that one is a knowledge owner or a knowledge provider does not necessarily make the person a knowledge broker. Knowledge brokers should not only receive knowledge from various sources but also spread such knowledge to the rest of the organization. Thus, it is the knowledge broker's role that is instrumental in promoting active knowledge transfer within an organization. Three types of knowledge brokers, adopted in this study, are coordinator, gatekeeper, and representative based on Gould and Fernandez's (Gould and Fernandez, 1989) classifications. First, a coordinator intermediates knowledge transfer within a business unit (all three actors – source, recipient, and broker – belong to the same group). Second, both gatekeeper and representative play the ''boundary spanner'' role (Cross and Prusak, 2002), where they intermediate between different business units. A gatekeeper imports knowledge from other business units and spread it within his/her own unit. In contrast, a representative exports knowledge from his/her business unit to the rest of the organization.

In Alpha's case, these knowledge brokering roles seem to be mostly conducted by a small number of people in the organization. About 74 percent of the coordinating role is concentrated in the top 20 percent of the company's population, while, for the gatekeeper and representative roles, such concentration becomes even more extreme with approximately a 75/15 distribution. At Alpha, a typical broker (coordinator, gatekeeper, representative) is an associate general manager and is prominently found in the management supporting unit for implementing CEO's orders. These findings suggest that Alpha seems to have a fairly conservative and centralized knowledge transfer culture where, within business units, knowledge gets spread by the higher rankers but, across the organization, the unit supporting the CEO (the management supporting unit) plays the most important inter-unit knowledge brokering roles (gatekeeper, representative).

4.3 Cross-case comparisons

In the within-case analysis section, the authors looked into the knowledge flow network as well as the knowledge node roles of a single company Alpha (oil refinery). While it exposes meaningful, otherwise hidden, knowledge flow patterns, it will be more convincing if the authors synthesize and derive more generalized patterns through the cross-case comparisons. The results of the knowledge flow network structure analysis of the six participating organizations on five social network indices are summarized in Table III.

First, the average geodesic distance of the entire six firms is 5.71, suggesting that the organization, to some extent, has a sticky process of promulgating critical knowledge to its members. While Delta (investment and securities trading), which has launched a smart-working environment for both effective work and social meetings, has relatively short distances (4.31), Epsilon (hospital), whose organizational members' turnover rate is high (about 30 percent per year), shows a rather long distance (6.79). This seems to suggest that close social relations among organizational members play a critical role in shortening the average geodesic distance of a firm's knowledge flow network (Newman, 2003), suggesting a need to reinforce communications with social interactions.

Second, an overall giant component percentage is about 94 percent, which means that about six out of one hundred people in the six organizations is not connected to the main knowledge cluster, thus, subjecting themselves to ''knowledge disadvantage''. Identifying and helping such personnel get connected with the rest of the organization will be an important task beneficial to both the individuals and the organization. Third, clustering coefficient was the highest (0.41) for Epsilon where hundreds of doctor-nurse groups form a very tightly connected local unit of work, constantly exchanging knowledge and information among themselves but maintaining a rather loose connection outside their groups. Fourth, network densities of the six firms were mostly quite low (ranging from 0.01 to 0.03). This is not surprising since, unlike the other studies based on team or department-level networks, this

study examined the corporate-level social networks of the firms with thousands of employees.

Finally, in accordance with the authors' expectations to observe a fair level of variance across organizations (since all of them belong to different industries), degree of concentration was the highest (0.824) for Delta where a select group of professionals (analysts, fund managers) produce bulk of the financial knowledge for the rest of the people working at hundreds of branch offices. In contrast, at Alpha and Beta (telecommunications service) where bulk of the required knowledge disseminates from the daily operations of the oil refining or telecommunication services, degree of concentration was the lowest (0.282 for Alpha, 0.277 for Beta), reflecting the even distribution of knowledge providers across the entire organization.

The blockmodeling analysis on both within and inter-unit knowledge flows show that six organizations' within-unit knowledge flow portion ranges from 61 percent (Delta) to 95 percent (Beta) with an average of 79 percent. Thus, within-unit vs inter-unit knowledge flow ratio seems to be roughly 8:2. Additionally, blockmodeling analysis on inter-management level shows that the average portions of downward, horizontal, and upward knowledge flows between management levels are 41, 37, and 23 percent, respectively, confirming that the downward knowledge flows are dominant over the horizontal and upward knowledge flows.

Both knowledge owners and providers in each of the six case companies seem to have very similar distribution patterns (e.g. L-shape, increasing as the management level goes up, etc.). However, while knowledge owners, as shown in Table IV, usually peak at the general manager level, knowledge providers seem to peak at the associate general manager or the general manager level. Interestingly, the gap between knowledge owning and providing is significantly expanding as the management level goes up. It further suggests the need to motivate the high rankers (especially general managers) to contribute their knowledge more actively.

Table IV also shows that the top 20 percent people in an organization dominate over 72 percent of brokerage activities while only about 54 percent of knowledge owning and providing activities are explained. These results imply that identifying and motivating knowledge brokers (rather than owners or providers) are more critical for an effective organizational knowledge transfer. Among the knowledge brokers, more specifically, the case comparison results imply that focusing on inter-unit knowledge transfer by motivating the boundary spanners' (gatekeeper or representative) role (88/20) is likely to be more effective than paying attention to the coordinators' role (72/20).

5. Discussion

Through multiple case studies in six different industries, this study sheds a new light on how to comprehend the features of knowledge flow and the role-specific nodes in knowledge networks by applying SNA to practices as follows:

Table IV The summarized results of analyses on knowledge node aspects in six case companies

	KOA		*KPA*		*Gap (EP-KPP)*	*KBA Coordinator*		*KBA Gatekeeper*		*KBA Representative*	
Company	*Top 20%*	*Peak*	*Top 20%*	*Peak*	*Peak*	*Top 20%*	*Peak*	*Top 20%*	*Peak*	*Top 20%*	*Peak*
Alpha	58.1%	AG	52.4%	AG	AG	73.6%	AG	84.8%	AG	84.2%	AG
Beta	55.6%	GM	56.3%	GM	EP	81.5%	EP	100%	EP	100%	GM
Gamma	67.4%	GM	60.1%	GM	GM	74.4%	GM	84.8%	AG	84.2%	AG
Delta	53.2%	AG	49.3%	AG	AG	66.5%	AG	73.6%	AG	73.5%	AG
Epsilon	61.7%	GM	52.8%	GM	GM	64.2%	MG	100%	GM	100%	MG
Zeta	59.4%	GM	50.8%	AG	AG	73.4%	AG	82.6%	GM	85.4%	GM
Average	59.2%	GM	53.6%	AG or GM	AG	72.3%	AG	87.6%	AG	87.9%	AG

Notes: *KOA: Knowledge owner analysis; KPA: Knowledge provider analysis; KBA: Knowledge broker analysis; EP: Expertise point; KPP: Knowledge provision point; AM: Assistant manager; MG: Manager; AG: Associate general manager; GM: General manager

1. The results of the blockmodeling analysis show that the within-unit knowledge flows are more dominant over the inter-units knowledge flow. Since organizational units are usually formed to accomplish specific goals common to their members, it will be natural for organizational members to share more knowledge within their unit rather than with other units to meet the goals. Therefore, it is likely that the inter-unit knowledge flows are more dominant than the within-unit knowledge flow where different units have common goals to meet in collaboration. The dominant within-unit knowledge flows over the inter-units flow may result from proximity of organizational members within a unit and shared context and relevancy of knowledge within the unit. They makes it easier and more common to share knowledge among organizational members in the same unit.
2. The blockmodeling analysis also indicates that the downward knowledge flows are dominant over the horizontal and upward knowledge flows in the management levels, which is in accordance with the common sense in practice. But this analysis result provides meaningful evidence that managers in practice should find out ways of facilitating the bottom-up flow of knowledge.
3. The analyses about the knowledge node aspects show that distributions of knowledge owners and providers are like L-shape and the gap between knowledge owing and providing expands as the management levels go up. This means that knowledge owing and providing is not evenly spread but mostly concentrated to the top 20 percent people in organizations and that the high rankers (especially general managers) do not contribute their knowledge as actively as their subordinates expect them to. This result may reflect the knowledge sharing dilemma (Cabrera and Cabrera, 2002) in which hoarding knowledge seems more beneficial than sharing it with others. Knowledge itself can mean a source of power to individuals (Cabrera and Cabrera, 2002). So, knowledge owing and providing can be limited as organizational members have a tendency to hide it to increase their power in their organizations. In line with this tendency in the knowledge sharing dilemma, the higher rankers may be reluctant to share knowledge for fear of losing their power.
4. The analyses about the knowledge node aspects also point out that the top 20 percent people in an organization dominate over 72 percent of the knowledge brokerage activities. This shows that the degree of concentration in the activity of knowledge brokering is very high and implies that it is very important to identify the top 20 percent people and provide them with focused support for facilitating their knowledge brokering activity. And it can be equally or even more important to find out ways of tapping the ''long tail'' of the L-shaped distribution of the brokerage activities because it may work as a major conduit for important knowledge which is relevant but hard to find or share due to its sparse distribution.

6. Conclusion

This study, based on multiple cases, provides important implications for managers and KM scholars. As the implication for managers, this study suggests that managers should have a solid grasp about knowledge flows and knowledge node roles in their organization in order to facilitate the knowledge transfer and eliminate the knowledge link lapse among organizational members. Through the knowledge flow network map in the authors' analysis, managers can clearly figure out the knowledge flow similar to the way doctors diagnose their patients with x-ray films. The structural analyses and blockmodeling analysis can be very useful to identify and assess the knowledge flow paths and the analyses about the knowledge node can help managers to comprehend the features of the role-specific nodes in organizational knowledge networks.

For KM scholars, this study shows that deeper understanding of the organizational knowledge paths can make it possible for more context-specific KM strategies (e.g. suitable for a specific functional unit, management level, or industry type) to be identified and implemented. This study could be a stepping stone for further empirical research since it

expanded the level of organizational knowledge network analysis from individual and team to inter-unit and inter-management level through block modeling analysis.

Despite such implications, there are several limitations to this study, requiring further examinations. First, the authors identified the knowledge paths but did not measure the actual knowledge flows in the six organizations. Second, because data collection was limited to Korean organizations, cultural difference issue might arise. Lastly, more considerations on types of knowledge in the future study would produce more relevant findings.

References

Allen, J., James, A.D. and Gamlen, P. (2007), ''Formal versus informal knowledge networks in R&D: a case study using social network analysis'', *R&D Management*, Vol. 37 No. 3, pp. 179-196.

Burt, R.S. (1984), ''Network items and the general social survey'', *Social Networks*, Vol. 6 No. 4, pp. 293-339.

Cabrera, A. and Cabrera, E.F. (2002), ''Knowledge-sharing dilemmas'', *Organization Studies*, Vol. 23 No. 5, pp. 687-710.

Chiu, C.-M., Hsu, M.-H. and Wang, E.T.G. (2006), ''Understanding knowledge sharing in virtual communities: an integration of social capital and social cognitive theories'', *Decision Support Systems*, Vol. 42 No. 3, pp. 1872-1888.

Chow, W.S. and Chan, L.S. (2008), ''Social network, social trust and shared goals in organizational knowledge sharing'', *Information and Management*, Vol. 45 No. 7, pp. 458-465.

Chung, Y. and Jackson, S.E. (2013), ''The internal and external networks of knowledge-intensive teams: the role of task routiness'', *Journal of Management*, Vol. 39 No. 2, pp. 442-468.

Cross, R. and Prusak, L. (2002), ''The people who make organizations go-or stop'', *Harvard Business Review*, Vol. 80 No. 6, pp. 104-112.

Cross, R., Nohria, N. and Parker, A. (2002), ''Six myths about informal networks-and how to overcome them'', *MIT Sloan Management Review*, Vol. 43, pp. 67-75.

Cross, R., Thomas, R.J. and Light, D.A. (2009), ''How 'who you know' affects what you decide'', *MIT Sloan Management Review*, Vol. 50 No. 2, pp. 35-42.

Cross, R., Thomas, B.O.B., Dutra, A.N.A. and Newberry, C. (2007), ''Using network analysis to build a new business'', *Organizational Dynamics*, Vol. 36 No. 4, pp. 345-362.

Cross, R., Gray, P., Cunningham, S., Showers, M. and Thomas, R.J. (2010), ''The collaborative organization: how to make employee networks really work'', *MIT Sloan Management Review*, Vol. 52.

Cyram (2008), ''NetMiner 3'', Cyram Co., Ltd., Seoul, available at: www.netminer.com/index.php (accessed 10 March 2013).

Doreian, P., Batagelj, V. and Ferligoj, A. (2005), ''Positional analyses of sociometric data'', in Carrington, P.J., Scott, J. and Wasserman, S. (Eds), *Models and Methods in Social Network Analysis*, Cambridge University Press, New York, NY, pp. 77-97.

Gould, R.V. and Fernandez, R.M. (1989), ''Structures of mediation: a formal approach to brokerage in transaction networks'', *Sociological Methodology*, Vol. 19, pp. 89-126.

Hansen, M.T. (1999), ''The search-transfer problem: the role of weak ties in sharing knowledge across organization subunits'', *Administrative Science Quarterly*, Vol. 44 No. 1, pp. 82-111.

Hansen, M.T. (2002), ''Knowledge networks: explaining effective knowledge sharing in multiunit companies'', *Organization Science*, Vol. 13 No. 3, pp. 232-248.

He, W., Qiao, Q. and Wei, K.-K. (2009), ''Social relationship and its role in knowledge management systems usage'', *Information & Management*, Vol. 46 No. 3, pp. 175-180.

Huang, C.Y., Shen, Y.C., Chiang, I.P. and Lin, C.S. (2007), ''Concentration of web users' online information behaviour'', *Information Research*, Vol. 12 No. 4.

Huysman, M. and de Wit, D. (2002), *Knowledge Sharing in Practice*, Kluwer Academic Publishers, Dordrecht.

Levin, D.Z. and Cross, R. (2004), ''The strength of weak ties you can trust: the mediating role of trust in effective knowledge transfer'', *Management Science*, Vol. 50 No. 11, pp. 1477-1490.

Marsden, P.V. (2005), ''Recent developments in network measurement'', in Carrington, P.J., Scott, J. and Wasserman, S. (Eds), *Models and Methods in Social Network Analysis*, Cambridge University Press, New York, NY, pp. 8-30.

Newman, M.E.J. (2003), ''The structure and function of complex networks'', *SIAM Review*, Vol. 45, pp. 167-256.

Phelps, C., Heidl, R. and Wadhwa, A. (2012), ''Knowledge, networks and knowledge netoworks: a review and research agenda'', *Journal of Management*, Vol. 38 No. 4, pp. 1115-1166.

Reagans, R. and McEvily, B. (2003), ''Network structure and knowledge transfer: the effects of cohesion and range'', *Administrative Science Quarterly*, Vol. 48 No. 2, pp. 240-267.

Schweer, M., Assimakopoulos, D., Cross, R. and Thomas, R.J. (2012), ''Building a well-networked organization'', *MIT Sloan Management Review*, Vol. 53 No. 2, pp. 35-42.

Simon, R. and Galunic, C. (2004), ''More than network structure: how knowledge heterogeneity influences managerial performance and innovativeness'', *Strategic Management Journal*, Vol. 25 No. 6, pp. 541-562.

Singh, J., Hansen, M.T. and Podolny, J.M. (2010), ''The world is not small for everyone: inequality in searching for knowledge in organizations'', *Organization Science*, Vol. 56 No. 9, pp. 1415-1438.

Spencer, J.W. (2003), ''Global gatekeeping, representation, and network structure: a longitudinal analysis of regional and global knowledge-diffusion networks'', *Journal of International Business Studies*, Vol. 34 No. 5, pp. 428-442.

Tsai, W. (2002), ''Social structure of 'coopetition' within a multiunit organization: coordination, competition, and intraorganizational knowledge sharing'', *Organization Science*, Vol. 13 No. 2, pp. 179-190.

Wasko, M.M. and Faraj, S. (2005), ''Why should I share? Examining social capital and knowledge contribution in electronic networks of practice'', *MIS Quarterly*, Vol. 29 No. 1, pp. 35-57.

Wasserman, S. and Faust, K. (1994), *Social Network Analysis: Methods and Applications*, Cambridge University Press, New York, NY.

Watts, D.J. and Strogatz, S.H. (1998), ''Collective dynamics of 'small-world' networks'', *Nature*, Vol. 393 No. 6684, pp. 440-442.

Whelan, E., Parise, S., Valk, J.d. and Aalbers, R. (2011), ''Creating employee networks that deliver open innovation'', *MIT Sloan Management Review*, Vol. 53 No. 1, pp. 37-44.

Yang, S.-B. and Kim, Y.-G. (2007), ''Inter-organizational knowledge transfer in the buyer-supplier relationship: a buyer's perspective'', *Proceedings of 40th Annual Hawaii International Conference on System Sciences*, IEEE Computer Society.

About the authors

Young-Gul Kim is a Professor at KAIST Business School. His main research areas are knowledge management and customer relationship management.

Yong Sauk Hau is an Assistant Professor at School of Business in Yeungnam University. His research is focused on knowledge management and open innovation. Yong Sauk Hau is the corresponding author and can be contacted at: augustine@yu.ac.kr

Seulki Song is a Consultant in CYRAM which is a social network data mining company.

Ghi-Hoon Ghim is the CEO of CYRAM.