

Knowledge Transfer in Information Systems Support Community: Network Effects of Bridging and Reaching

Completed Research Paper

Lei Chi

Lally School of Management & Technology
Rensselaer Polytechnic Institute
Troy, NY 12180
chil2@rpi.edu

Xuefei (Nancy) Deng

University of Hawaii at Manoa
2404 Maile Way
Honolulu, HI 96822
xuefei@hawaii.edu

Abstract

The support of a new information system in an organization is a knowledge-intensive setting (which we refer to as an IS support community) where IS professionals engage in frequent knowledge sharing activities with organizational users and provide users with knowledge, diagnoses and solutions in a timely manner. In this paper, we drew upon perspectives from social networks and knowledge transfer literature to specifically examine two network characteristics of an IS support community – bridging and reaching – and their effects on knowledge transfer. Bridging is examined through Burt's (1992) structural holes. Reaching is examined through Valente and Forman's (1998) measure of radiality, a variation of closeness centrality measure. Effect of knowledge transfer is captured through an IS support professional's productivity measured as the ticket resolution time. We collected archival data comprising 11,409 system usage problem records reported by 2,000+ users in the supply chain function over a 10-month post-implementation period of a new enterprise system in a large U.S. organization. We analyzed the data using social network analysis and analysis of covariance. Our results show strong support for our hypotheses that network bridging and reaching are positively related to an IS support professional's productivity. Our study has important implications for IS theory and practice.

Keywords: IS support community, network bridging, network reaching, productivity

1. Introduction

The ability to transfer knowledge effectively between IS professionals and users in the organization is critical to organizational learning and use of information systems (IS). Prior research has highlighted the positive role that IS professionals play in facilitating organizational learning of system use (Pawlowski and Robey 2004; Santhanam et al. 2007). The support of a new information system in an organization is a knowledge-intensive setting where IS professionals engage in frequent knowledge sharing activities with organizational users and provide users with information, knowledge, diagnoses and solutions in a timely manner (Das 2003). While prior studies offer useful insights in organizational users' learning behaviors during IS post-implementation phase, we argue that substantial new insights can be gained by focusing on the knowledge exchange between IS professionals and users during IS support services, and on factors contributing to the performance improvement of those IS professionals. In this paper, we take a network perspective and examine the IS support community which comprises of both IS users (organizational employees) who use the system to accomplish their business tasks and IS professionals (also referred to as "IS support personnel") who provide support services on system use and maintenance. We argue that knowledge resides in the experience and expertise of individuals and in the collective actions of community participants enabled by their shared communication channels (Hansen et al. 1999; Szulanski 1996). Collective learning and problem-solving among IS professionals and users in the IS support context underlies a crucial knowledge transfer process. IS professionals' network positions in the IS support community can exert an important influence on the knowledge transfer between support professionals and users, subsequently affecting those support personnel's performance in resolving system usage problems.

We specifically focus on two network characteristics of the IS support community – bridging and reaching – and examine their performance effects on knowledge transfer. Bridging is a network characteristic that has been widely recognized as having an important influence on knowledge transfer. Bridging helps connect disconnected ideas, information and knowledge in the network and enables information to flow more rapidly through the network (Granovetter 1973). In addition to bridging, reaching is another network characteristic that has an important influence on knowledge transfer. High reachability in the network enables an individual to reach out into the network and have fast access to novel information and knowledge of many and diverse network members.

In this study, we posit that in the IS support community, bridging and reaching can have important effects on the knowledge transfer between support personnel and users, subsequently influencing the support personnel's productivity. Productivity here particularly refers to a support person's efficiency in completing a support task (i.e., resolving a user-reported system usage problem). To test the effects of bridging and reaching on IS support personnel's productivity, we collected archival data comprising 11,409 system usage problem records (identified by ticket number) reported by 2,000+ users in the supply chain function over a 10-month post-implementation period of a new enterprise system, SAP/R3, in a large U.S. organization. We analyzed the data using social network analysis and analysis of covariance. Our data analysis results indicate that both network bridging and reaching have a significant and positive impact on the productivity of IS support professionals. Our study offers new insight into the traditional arguments on the path-dependency of experience learning and absorptive capacity, which emphasize that individuals build their capability from prior stock of experience and knowledge (Levinthal and March 1993). Moreover, our study suggests several ways through which IS professionals can take advantage of their network positions to improve their productivity.

The remaining of the paper is organized as follows. Section 2 introduces the theoretical background and research hypotheses. Section 3 describes research methods, followed by data analysis and results in section 4. Section 5 highlights research contributions and section 6 concludes the paper with limitations and directions for future research.

2. Theory and Hypotheses

Knowledge Transfer in IS Support Community

Knowledge transfer refers to "the process by which one unit of an organization, such as a group or department, is affected by the experience of another" (Argote and Ingram 2000, p. 151). Consistent with prior research (e.g., Kane et al. 2005; Ko et al. 2005), this study adopted this definition to suggest that

individuals engaging in this process learn and apply the knowledge in performing their respective tasks. When a knowledge recipient understands the rationales and consequences associated with a piece of knowledge, the knowledge is transferred.

Deployment of a new information system always creates new challenges for employees as they cope with new work processes and technology features (Robey et al. 2002). In particular, learning about a new information system requires understanding of the conditions under which a system feature is used. For example, employees not only need to understand the conceptual and procedural knowledge about system functionalities, but also need to understand how to apply a system's functionality to support their daily routine jobs. Under these circumstances, IS professionals become one of the major sources of knowledge for organizational end-users, as organizations often rely on their IS departments to train employees on using new systems and to resolve system usage problems encountered by end-users. The knowledge-intensive work of IS professionals have been evidenced in prior studies on systems' post-implementation phase during which IS professionals interact with organizational end-users and help them overcome knowledge barriers in using a new system (Das 2003, Pawlowski and Robey 2004, Santhanam et al. 2007).

Meanwhile, IS professionals who support the system also benefit from their interactions with organizational end-users because those support personnel acquire knowledge about local business processes and about how system features meet the employees' information requirements (Santhanam et al. 2007). Moreover, when those support personnel repeatedly interact with the same groups of end-users, they acquire more knowledge about users' system use behaviors and about the common areas of problems among end-users. When they apply this acquired knowledge to resolving incoming system use problems, they are likely to locate the needed information and to perform the problem diagnosis more efficiently (Das 2003). Thus, knowledge transfer is evidenced in the IS support community, which consists of employees who access to and use a new system and IS professionals who support the system. Effective knowledge transfer between the IS support professionals and users is likely to affect support personnel's performance outcomes (in particular, productivity).

On the other hand, structural characteristics of knowledge networks have been widely found to significantly affect knowledge transfer (e.g., Hansen 1999; Reagans and McEvily 2003). In this study, we specifically examine two network characteristics in the IS support community – bridging and reaching. Bridging in the network is often captured through structural holes (Burt 1992), which exist between two individuals who do not have direct links with each other but are connected through a third person. People who span structural holes can have an early access to diverse information and interpretations from diverse sources which increase their potential to see good ideas and synthesize them to create value than people who do not span structural holes (Burt 2004). Thus, structural holes present opportunities for brokering knowledge flows in the network and influencing knowledge transfer among between the hole-spanning individuals and other network members. While structural holes are considered to be a local measure, which captures bridging by measuring the diversity and nonredundancy of an individual's direct ties, network reachability is often captured by closeness centrality. Closeness centrality is a global measure, which goes beyond direct ties and measures the diversity of ties by also considering the indirect ties of an individual. Indirect ties are important to consider as they not only influence an individual's manipulation of the network but also provide channels through which socially distant ideas, information and knowledge can reach the individual (Granovetter 1973).

Taken together, in this paper, we present an overview of knowledge transfer as occurred in a community of IS users and support personnel, and we examine how a support person's network position affects the his/her productivity through influencing knowledge transfer in the community. We posit that spanning structural holes can provide a support person with unique advantage in bridging the flow of rich yet novel information and knowledge among diverse users, which helps enhance his/her productivity. Meanwhile, possessing high closeness centrality increases a support person's capacity to reach a large number of users in the support community, which facilitates the support person's acquisition of in-depth task-related knowledge and enhances his/her productivity. We next develop detailed hypotheses.

Structural Holes, Knowledge Transfer and Productivity

In supporting a newly implemented information system, IS professionals usually work independently to assist end-users with their system use problems, because system use problems are often assigned to

individual support personnel instead of to a support team. Therefore, a support person's learning from interacting with users in the community directly affects the overall quality of IS support service in two ways. First, in the IS support community, the interactions among users and support personnel enable the participants to convey their knowledge and perspectives (to influence others). Second, as a result of the interactions in the community, participants, such as IS professionals, are more likely to utilize others' insights and expertise (to identify problem solutions) to enhance their performance. The pattern of linkages among these individuals and the relationships built through them not only provide them with opportunities to better identify new knowledge and expertise, but also to serve as channels for mobilizing these knowledge and expertise among them.

Structural holes occur when two individuals are not connected directly to each other but each is connected to different groups of people in a network (Burt 1992). Distinct information and knowledge tend to circulate among people on different sides of a structural hole. A number of prior studies have found a positive relationship between structural holes and individual performance because individuals spanning structural holes are in an advantageous position to access to diverse and non-redundant knowledge, which may contribute to their performance improvement. For example, in their analysis of corporate research and development teams, Reagans and Zuckerman (2001) found that bridging structural holes in the knowledge network enabled the scientists to access and share with each other diverse knowledge, resulting in greater creativity and improving the team's overall productivity.

Extending these prior findings (Granovetter 1973) to the context of the IS support community, we posit that individual support personnel is likely to benefit from a structural hole for two reasons. First, when an IS support person spans a structural hole by directly communicating with different user groups, who don't have direct ties between them, the support person is likely to have access to new and non-redundant information that circulates within those user groups on different sides of the structural hole. This access to diverse bodies of knowledge not only enables a support person to build a good understanding of user groups' diverse business contexts and information needs but also motivates the support person to consider multiple perspectives and frames his solutions and communications to fit the context of a particular user group. This suggests that the structural hole access may lead to better performance of the support person in resolving users' system use problems, because of the diverse bodies of knowledge transferred and assimilated for diagnosing and resolving those problems.

Second, spanning structural holes allows a support person to accumulate experience working with diverse user groups. Organizational learning and management scholars have evidenced the positive impact of variation in experience learning (e.g., Schilling et al. 2003). Experience in supporting different user groups may expose individuals to various sources of knowledge and to diverse customers' needs, enhancing their problem-solving and learning ability. Individuals' learning ability not only lies in their ability to transfer the content knowledge gained from one problem domain to a new unit of task in the same domain, but also lies in their ability to assimilate or process acquired information and knowledge to a new and different problem domain (Ellis 1965). Similarly, IS professionals interacting with a variety of user groups and supporting different types of service requests are likely to learn better about users' problems and needs, so that they are able to provide solutions to users more quickly. Therefore, we propose the following:

HYPOTHESIS 1 (H1): The extent to which an IS support person accesses to structural holes in the IS support community is positively related to the support person's productivity.

Closeness Centrality, Knowledge Transfer and Productivity

While structural holes reflect an individual's capacity to access to new and unique information in the network based on the individual's direct ties, closeness centrality reflects an individual's capacity to access to a large amount of information in the network by considering both direct ties and indirect ties of the individual. When an individual is positioned within proximity to a large number of other people in the network, then the individual possesses a high closeness centrality. Knowledge spillover occurs when knowledge of a third unconnected person is passed to an individual from another person (who is directly connected with the third person). The effects of knowledge spillover attenuate exponentially as knowledge passes from one person to another along the chain in the network. Possessing a high closeness centrality in the network enables an individual to have early access to diverse knowledge of many others either through direct communication or indirect knowledge spillover.

In the IS support community, a support person with a high closeness centrality is able to quickly reach out into the network and have fast access to knowledge of many users (through both direct ties and indirect ties). When a support person is able to reach a large number of users and have fast access to their knowledge about problems, the support person is likely to gain more experience and expertise in resolving users' problems. Thus, having a high closeness centrality enables a support person to build in-depth knowledge about system use problems and resolution strategies, increasing his/her productivity. Besides benefiting from knowledge transfer from users, an IS support person can also benefit from other IS professionals in terms of learning about resolution strategies and about technical functions of the system. When a support person possesses a high closeness centrality, he/she is more likely to reach a larger number of other IS professionals indirectly through interacting with users. Thus, the support person is likely to benefit from other IS professionals' expertise and knowledge. As a result, the support person is likely to improve his/her efficiency in identifying problem causes and developing resolution strategies. Thus, we propose the following:

HYPOTHESIS 2 (H2): Closeness centrality of an IS support person in the IS support community is positively related to the support person's productivity.

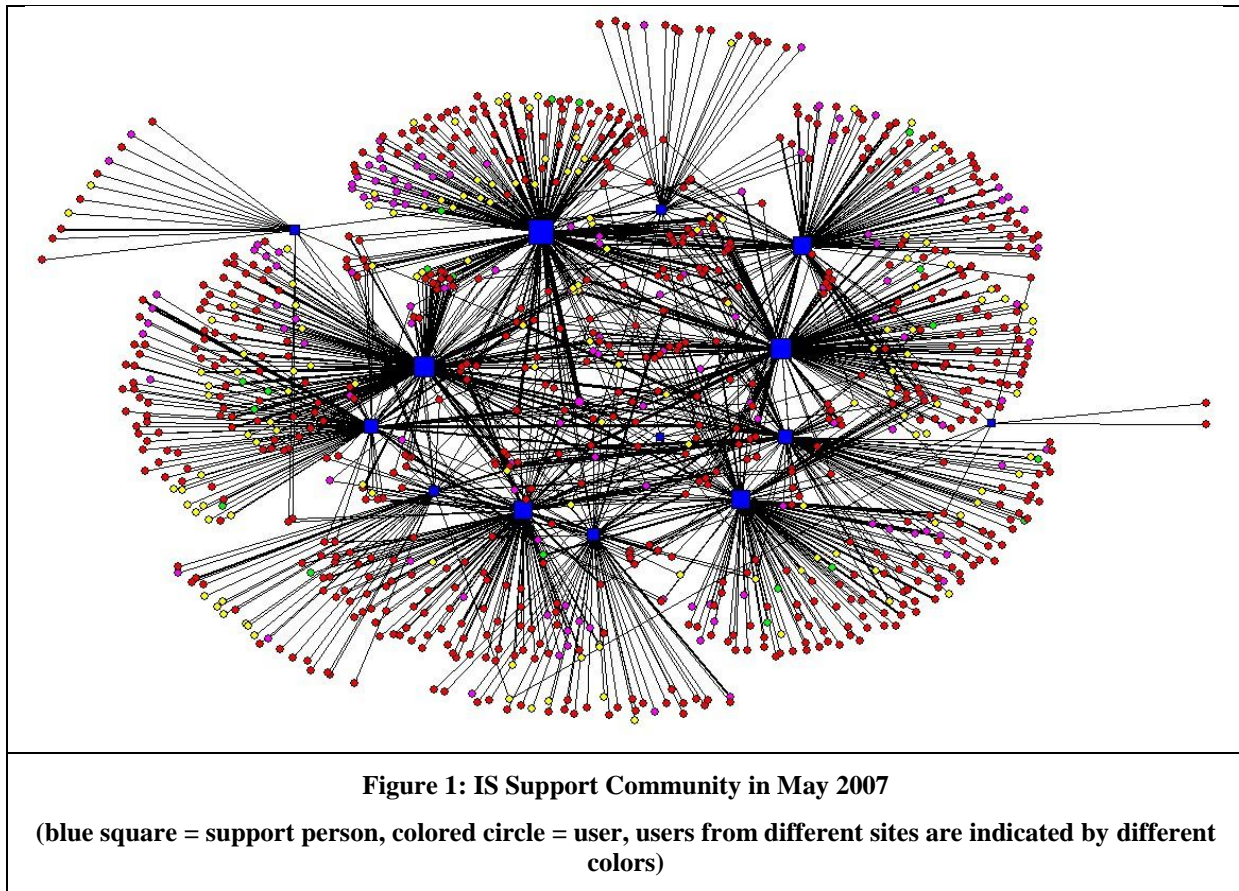
3. Methods

Research Setting and Data Collection

The study focuses on the post-implementation of an enterprise system SAP/R3 across four organizational sites at a large private enterprise in the northeastern region of the United States. Prior to its SAP/R3 implementation, the organization operated under a decentralized governance structure; the four organizational sites operated independently, not only in their primary functions (e.g., patient care vs. education and research) but also in their administrative functions such as human resources, accounting, and supply management. To serve its non-integrated business processes, the organization had developed and purchased over 1,000 disparate information systems over the last three decades. The enterprise system, SAP/R3, was adopted and implemented to integrate and streamline many of its business functions. With a three-year implementation at the cost of \$200 million, the SAP/R3 system went live in January 2007. A Support Center was set up and became solely responsible for providing a centralized support services for 11,000 employees throughout the four different organizational sites.

This study focuses on the IS support community formed by end users of the organization and IS professionals who support SAP/R3 at the Support Center. A ticket tracking system was installed three-month after the go-live to facilitate the Support Center's operation and employees' learning. Employees at the research site had two channels to report their system use problems: phone calls or emails. The majority of system use problems were called in, while about 25% to 30% (according to the support center manager's estimate) of the problems were reported via e-mails. Both emailed and phoned problems were logged in the tracking system with description of the problem and contact information of the reporting employees.

Data analysis under this study covers the first 10 months post-implementation of the SAP/R3 system, starting from the initial large-scale use of the new system in May 2007 to February 2008. The SAP/R3 system implemented at the organization has four standard modules, including Human Resource/Payroll, Supply Chain, Sponsored Projects and Finance. The characteristics (e.g., complexity, number) of ticket problems related to each module may differ and subsequently influence the ticket resolution and thus productivity of support personnel. As an initial effort in this study, we focus on the Supply Chain module of the SAP/R3 to exclude this potential confounding factor. In total, we extracted 11,409 system use problem records (identified by ticket number) reported by 2,000+ users in the Supply Chain module for the period 5/2007-2/2008 for examining new system-related problems and ticket problem solving process. Each problem record contains data on the sequence of activities in solving a system usage problem, from the problems' origin, to its categorization and assignment, and to the final resolution of the problem. Figure 1 visualizes this IS support community in May 2007.



Knowledge Transfer Activities between IS Support Professionals and End-Users

Knowledge transfer is evidenced from each system use problem reported. When a user (e.g., a purchasing agent) encountered a problem in using SAP/R3's supply chain module to perform a routine task (e.g. processing employee purchase orders), he would call the support center and describe the problematic incident, detailing the steps he performed on the system and the error message he received. This problem description often provided support team information on the business context where a system feature was actually applied. Then after the assigned support person followed the problem clues and diagnosed the problem, he would communicate directly with the employee who initially reported the problem, and guide the employee on how to resolve the problem. The process of opening and closing such a problem ticket reflects the process of knowledge transfer between IS support personnel and end-users. In other words, each problem ticket resembles an episode of knowledge transfer between a support person and a user. Moreover, the knowledge transferred was not only about new system features in the enterprise system context; it could also involve knowledge regarding the business process embedded in the system and the business process at the user groups.

For example, Chris was responsible for ordering medical equipment for the operating room at the hospital. He had no problem using the new supply chain system to create a purchase order, but then he had difficulty in locating his purchase order and had no idea of how to track the status of the purchase order. When the support person John received this problem request from Chris, he tracked that document number Chris reported, and identified the cause of the problem. Then he contacted Chris and explained to him how to resolve the problem, including assisting Chris to locate the approver for the purchasing order. During this interaction, the IS support person was able to transfer his knowledge about SAP/R3 enabled shopping cart workflow, as evidenced in the following problem resolution record:

{ "The solution was as follows for this incident: Walked customer through the process of going back onto the SRM shopping cart area and finding the cart. Changes had been made by the approver and

were sent back to the customer to accept the changes. Customer was successful in accepting the changes, and cart processed through to creation of a Purchase Order."} (Resolved at 5/11/2007)

4. Data Analysis and Results

Variable Measures

IS Professionals' Productivity in IS Support Service. As suggested by the nature of IS support work, we consider an end-user request as the basic unit of activity in the context of IS support. The main interest of our study is on the learning behavior of knowledge workers in IS support. Our field data and interviews suggest that each unit of support task (represented by each unique customer request) was assigned and completed by individual support person. Thus, we considered it appropriate to analyze productivity at the individual level.

A support individual's productivity is measured by his/her efficiency in completing support tasks (i.e., resolution time per ticket). As the labor cost of IS support personnel accounts for the largest component of the cost in IS support service (Adhikari 1994), we use a support personnel's resolution time per task (a user-reported problem) to measure the support person's productivity, which is consistent with the definition and measurement of productivity in a prior technical support study (Das 2003). It is an important measure for customer service quality as a quick resolution of customers' problems would enable the customers to perform their business tasks (i.e., to submit a purchase order or to track the delivery of surgical equipment ordered). In IT support service, an individual may be responsible for multiple support assignments during the same time period. To examine the reasonable resolution time a support person spent on each task, we computed a measure of *adjusted resolution time*, to approximate the time that individual spent on resolving support task. According to our field interviews with the Support Center manager, support personnel were fully devoted to resolving system use problems during the first year of the new system's implementation. Therefore, it is a reasonable assumption that those IS professionals' time was spent on support activities. As their daily workload (i.e. the total number of tickets assigned) varied, we took into account the daily ticket volume when we calculated the adjusted resolution time as a proxy of a support person's productivity. First, we assume that each individual at the Support Center devoted one unit of time per day on resolving the support tasks. Then, we first divide the daily resource (1 unit) across all the open requests on a particular day for each individual to obtain the daily share of resource per request. For example, if there were n tickets under "OPEN" status for a given day, then the resource (time) for a ticket on that day was calculated by "1/n." The total time for that ticket was then calculated by summing up the daily value of that ticket across all the days during which the ticket remained "OPEN" status. This calculation method is similar to those used in prior learning curve studies in software context (Boh et al. 2007; Narayanan et al. 2009).

To obtain network measures of structural holes and closeness centrality, we first constructed the network matrix of the IS support community. Based on ticket descriptions, we obtained information about who (IS support person) resolved which ticket from whom (IS user who reported the ticketed problem). When a support person resolved a user's ticketed problem, a tie was assigned between the support person and the user. In the ticket resolution process, the knowledge and information related to a system use problem could flow in both directions between the support person and the user. Each tie thus was treated as unidirectional or symmetric.

Structural Hole Access was obtained by subtracting one by network constraint. Network constraint measures an individual support person's lack of access to structural holes and was calculated as follows (Burt 199, p.54):

$$\text{Constraint}_i = \sum_j \left[P_{ij} + \sum_k P_{ik} P_{kj} \right]^2$$

where P_{ij} is the proportion of a : on relation of all his/her relations invested in user j , and $\sum P_{ik} P_{kj}$ indicates the extent to which another individual user k in which i has invested substantial time and resources is also connected to user j . In this case, for support person i , the user j is redundant to the extent that another i 's contact k is also connected to j . In our context of the IS support community, ticket resolution relations only exist between support personnel and users; the relations do not exist between support professionals nor between users. The term $\sum P_{ik} P_{kj}$ is reduced to 0,

and the *constraint* calculation thus is simplified as $\sum_j p_{ij}^2$. As such, the *structural hole access* score here is mostly determined by the number of users a support person has served. The larger the number of users, the smaller the p_{ij} , the smaller the *constraint* measure, and thus the larger the *structural hole access*. The values of *structural hole access* range from 0 to 1, and the higher values indicate a greater extent of access to brokerage opportunities for information benefits. The mean score we obtained here is 0.69.

Closeness Centrality is calculated using Valente and Foreman's (1998) measure of radiality, which is a variation of closeness centrality measure. This measure takes the average of the reverse geodesic (shortest) distance between two individuals to reflect the extent of connectedness and reachability of a developer to others in the IS support community. The calculation of closeness centrality of support person i is given as follows:

$$C(i) = \frac{\sum_{j \neq i} RD_{ji}}{N-1}$$

where RD_{ji} is the reverse distance computed from the geodesic distance between support person i and individual j . N is the network size of the IS support community. RD_{ji} is computed by finding the geodesic distance and then subtracting the geodesic distance from one plus the maximum value within the geodesic matrix. Each individual's closeness centrality score is then obtained by averaging their reversed distance scores to every other individual. Both the distance values for nodes not reachable to one another and the values on the diagonal are set to zero in the reversed distance matrix (Valente and Foreman 1998, pp. 92).

We used UCINET v6 (Borgatti et al. 2002) to compute both network measures of Burt's (1992) constraints and Valente and Foreman's (1998) radiality measure. The IS support network is an undirectional network because the interactions between IS support personnel and users involves two-way knowledge flows. Descriptive statistics of variable measures are presented in Table 1.

Table 1: Summary Statistics and Pearson Correlation Coefficients

	N	Mean	Std. Dev.	Min	Max	1	2
1. Productivity	91	0.51	0.75	0.06	4.00	-	
2. Structural Hole Access	121	0.69	0.42	0.00	1.00	-0.86***	-
3. Closeness Centrality	121	3.18	2.21	0.00	6.82	-0.51***	0.85***

*** p < 0.01, ** p < 0.05, * p < 0.1.

Data Analysis and Results

Monthly data were constructed over the first 10-month period of organizational use of a new SAP/R3 system. Due to the limitation of our data sample, we used the analysis of covariance (ANCOVA) (Wildt and Ahtola 1978) to test the hypotheses. ANCOVA employs built-in regression, controlling the covariates to predict the dependent variable; it then does an analysis of variance (ANOVA) on the residuals (the predicted minus the actual dependent variable) to see if the independent variables are still significantly related to the dependent variable after the variation due to the covariates has been removed. In this study, a support person's network position is the independent variable. Structural hole access and closeness centrality of the support person were analyzed separately as we are interested in examining their respective effects on the support person's productivity. Time (month) is treated as a "covariate" as it covaries with the dependent variable – a support person's productivity may change as he/she gains experiences with resolving more tickets over time. In addition, a support person's network position evolves over time and thus time (month) may affect network measures and also change their effects on the support personnel's productivity. To address this, we entered an interaction term between the network measures and time in the ANCOVA model. In ANCOVA, independent variables are conventionally categorical variables. In this study, we coded structural hole access and closeness centrality respectively into two levels: High (above mean and coded as 2) vs. Low (below mean and coded as 1). Doing so also

helps remove the interdependence among network measures. ANCOVA thus allowed us to examine group mean differences in productivity between the group with high structural hole access (or closeness centrality) and the group with low structural hole access (or closeness centrality) after controlling for the effect of time (month). Table 2 presents the ANCOVA results for productivity (adjusted ticket resolution time) with structural hole access as the independent variable and time (month) as the covariate. Hypothesis 1 which proposes a positive relationship between a support person’s structural hole access and his/her productivity is strongly supported. As shown in Table 2, the Type I SS for structural hole access (24.37) gives the between-group sum of squares that are obtained for the ANCOVA analysis. This measures the difference between the least squares means of productivity (adjusted ticket resolution time) of support personnel with different levels of structural hole access, without controlling for the covariate time (month). The Type III SS for structural hole access (6.91) gives the between-group sum of squares adjusted for the covariate. Both Type I and Type III tests are highly significant ($p < .0001$), indicating that there is a statistically significant difference between the productivity means due to structural holes even after controlling for the effect of covariate time (month). Significant interaction term ($p = 0.0231$) between structural hole access and time (month) suggests that time (month) changes the effect (slope) of structural hole access on productivity (adjusted ticket resolution time). Table 2 also gives parameter estimates of the adjusted mean difference in productivity by structural hole access.

Table 2: Analysis of Covariance for Productivity with Structural Hole Access as Independent Variable

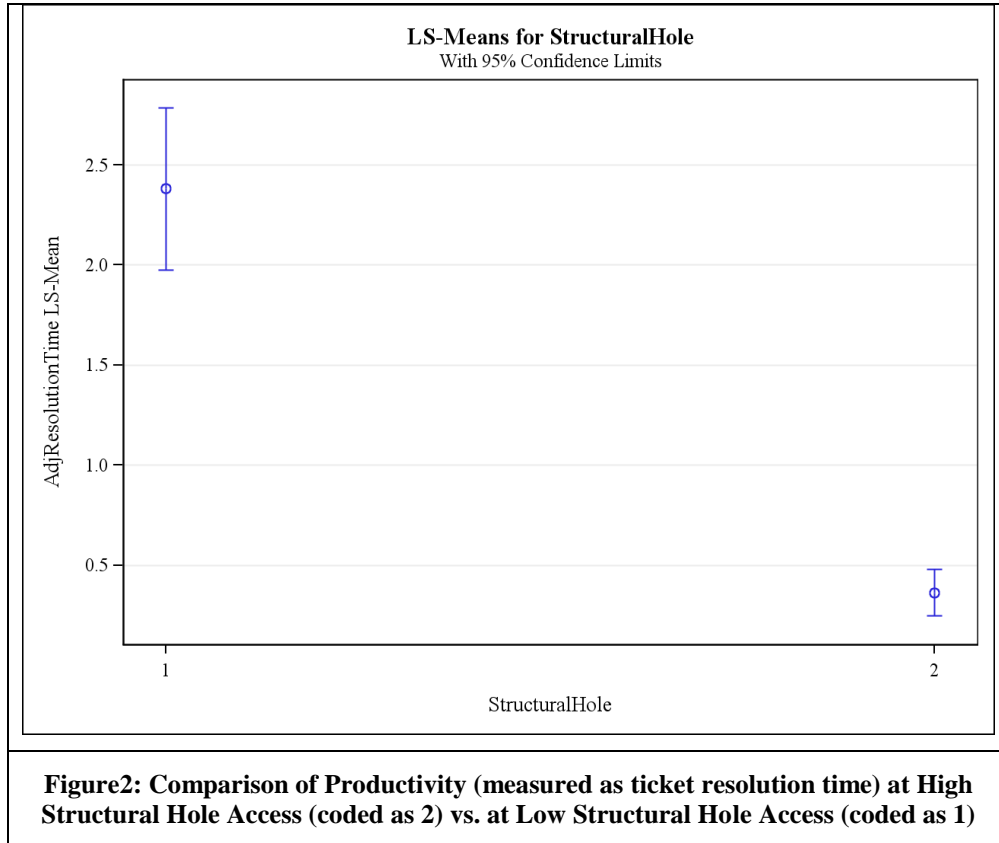
Dependent variable: Productivity (measured as Resolution Time)					
Independent variable: Structural Hole Access					
Control (Covariate): Time					
Source of Variance	DF	Type I SS	Mean Square	F	P
Structural Hole Access	1	24.37	24.37	85.83	<.0001
Time	1	0.27	0.27	0.96	0.3307
Structural Hole Access * Time	1	1.52	1.52	5.35	0.0231

Source of Variance	DF	Type III SS	Mean Square	F	P
Structural Hole Access	1	6.91	6.91	24.35	<.0001
Time	1	1.75	1.75	6.15	0.0151
Structural Hole Access * Time	1	1.52	1.52	5.35	0.0231

Overall Model Fit: $R^2 = 0.514$, $p < .0001$

Parameter	Estimate	Standard Error	t Value	Pr > t
Constant	0.42	0.19	2.20	0.0302
Structural Hole Access (Low)	3.54	0.72	4.93	<.0001
Structural Hole Access (High)	0.00	.	.	.
Time	-0.01	0.02	-0.30	0.7630
Time* Structural Hole Access (Low)	-0.17	0.07	-2.31	0.0231
Time* Structural Hole Access (High)	0.00	.	.	.

Figure 2 visualizes the significant difference in productivity means between different levels of structural hole access. From Figure 2, we see that IS support professionals with high structural hole access (coded as 2) demonstrated much higher productivity (reflected as shorter ticket resolution time 0.36) than productivity of those with low structural hole access (coded as 1) (reflected as longer ticket resolution time 2.38). These results suggest when a support person has a greater extent of structural hole access by working with diverse users from different sites, he/she is more likely to resolve ticket problems faster. These results suggest that by communicating with diverse users, a support person is more likely to learn faster and thus work more efficiently.



Hypothesis 2 which proposes a positive relationship between a support person’s closeness centrality and his/her productivity is also strongly supported. As shown in Table 3, the Type I SS for closeness centrality (3.47) gives the between-group sum of squares that are obtained for the ANCOVA analysis. This measures the difference between the least squares means of productivity of support personnel with different levels of closeness centrality, without controlling for the covariate. The Type III SS for closeness centrality (4.67) gives the between-group sum of squares adjusted for the covariate. Both Type I and Type III tests are highly significant ($p = 0.0108$; $p = 0.0033$), indicating that there is a statistically significant difference between the productivity means due to closeness centrality even after controlling for the effect of time (month). Significant interaction term ($p = 0.0256$) between closeness centrality and time (month) suggests that time changes the effect (slope) of structural hole access on productivity (adjusted ticket resolution time). Table 3 also gives parameter estimates of the adjusted mean difference in productivity by closeness centrality.

Table 3: Analysis of Covariance for Productivity with Closeness Centrality as Independent Variable

Dependent variable: Productivity (measured as Resolution Time)						
Independent variable: Closeness Centrality						
Control (Covariate): Time						
Source of Variance	DF	Type I SS	Mean Square	F	p	
Closeness Centrality	1	3.47	3.47	6.78	0.0108	
Time	1	0.19	0.19	0.37	0.5442	
Closeness Centrality * Time	1	2.64	2.64	5.16	0.0256	

Source of Variance	DF	Type III SS	Mean Square	F	p	
Closeness Centrality	1	4.67	4.67	9.11	0.0033	
Time	1	1.34	1.34	2.62	0.1093	
ClosenessCentrality * Time	1	2.64	2.64	5.16	0.0256	

Overall Model Fit: R= 0.124, p <.009

Parameter	Estimate	Standard Error	t Value	Pr > t
Constant	0.25	0.28	0.87	0.3843
Closeness Centrality (Low)	1.76	0.58	3.02	0.0033
Closeness Centrality (High)	0.00	.	.	.
Time	0.02	0.03	0.64	0.5248
Time* Closeness Centrality (Low)	-0.13	0.06	-2.27	0.0256
Time* Closeness Centrality (High)	0.00	.	.	.

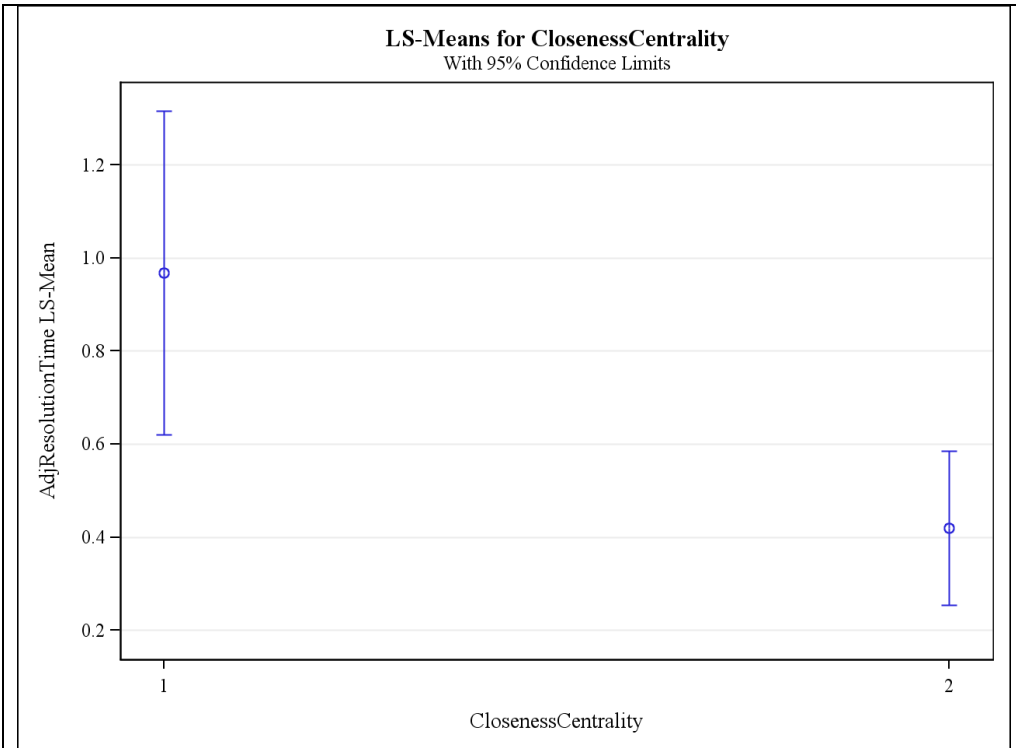


Figure 3: Comparison of Productivity (measured as adjusted ticket resolution time) at High Closeness Centrality (coded as 2) vs. at Low Closeness Centrality (coded as 1)

Figure 3 visualizes the significant difference in productivity means between different levels of closeness centrality. From the figure, we see that IS support professionals with high closeness centrality demonstrated higher productivity (reflected as shorter ticket resolution time 0.42) than productivity of those with low closeness centrality (reflected as longer ticket resolution time 0.97). These results suggest when a support person has a high closeness centrality by having fast access to a large number of network members, he/she is more likely to benefit from other users' and/or IS professionals' knowledge that helps resolve ticket problems faster. These results suggest that by having a high reachability to many network members (users and other IS professionals), a support person is likely to learn faster and thus work more efficiently. Results for closeness centrality, although not as strong as for structural hole access, further confirm that network position of a support person plays an important role in facilitating knowledge transfer between IS professionals and users and increasing the support person's productivity.

5. Contributions

Our study focused on examining the effects of two important network characteristics – bridging and reaching – on knowledge transfer in the IS support community of a new ERP post-implementation over 10 months. Bridging is examined through Burt's (1992) structural holes. Reaching is examined through Valente and Forman's (1998) measure of radiality, a variation of closeness centrality measure. Effect of knowledge transfer is captured through an IS support professional's productivity measured as the ticket resolution time. Our results show strong support for both of our hypotheses that structural hole access and closeness centrality of a support person are positively related to the support person's productivity. Our study contributes to the IS theory and practice in multiple ways.

First, this study contributes to literature on IS support by highlighting the important role of social interactions and network characteristics in enhancing knowledge transfer between IS support professionals and users during IS post-implementation use. The results from this study shed new insights into the importance of two network characteristics – bridging and reaching – in influencing knowledge transfer and individual performance. These results from our study complement findings from prior studies on learning curves and absorptive capability, which support the notion that individuals improve their performance and develop a capability to absorb, assimilate and apply new knowledge from their accumulated experience (Argote 1999; Levinthal and March 1993). In prior literature, the motivation and capability of knowledge source are two frequently cited factors contributing to effective knowledge transfer (Argote 1999). For example, Hansen (1999) found that strength of network ties significantly affected the types of knowledge that could be transferred. Reagans and McEvily (2003) found that network cohesion motivated knowledge source to transfer knowledge to the recipient. Results from our study suggest that network reachability (closeness centrality) and bridging (structural hole access) play an important role in increasing an IS support person's ability to transfer knowledge from end users and other IS professionals and identify problem solutions efficiently. In this regard, our study extends prior knowledge management literature by highlighting the positive effect of two key network characteristics in promoting knowledge transfer in a multi-stakeholder network.

Second, focusing on post-implementation enterprise system support, this study enhances our understanding of the performance of IS professionals in system support. Prior research present mixed views on the role of IT support desk in helping users learn a new system. For example, Santhanam and colleagues (2007) emphasized the effectiveness of IT help desk in transferring technical knowledge (know-how and know-what) to users. However, other studies (Govindarajuiu 2002) suggested that IT help desks are often overwhelmed and lacked business domain expertise in resolving users' problems. Thus, findings of this study help offer some practical explanations for the inconsistent views and suggest several ways to improve IS support service efficiency. For example, IS professionals could take advantage of their access to diverse user groups and share employees' commonly-experienced problems and resolutions among users. Another strategy would be to make users aware of potential problems and prevent those common system use problems from occurring. As IS support is increasingly viewed as the service offering between IS professionals and end-users (Carr, 2006), gaining an in-depth understanding of organizational end-users' expectation and evaluation of IS support service becomes valuable. To that end, organizations should allocate more resources in fostering relationship between IT support units and user groups so as to enhance IS service quality.

Third, this study also provides practical implications on evaluating and assessing the business value of information systems, such as SAP/R3, and highlights the significance of viewing stakeholders' value

creation from a network perspective. The post-implementation support of enterprise system provides both IS support professionals and end-users with opportunities to interact with multiple system modules and to enhance their utilization of the new IT system. Through identifying and resolving the problematic system use incidents with regard to the integrated system (e.g., SAP/R3), the IS support community not only enhances their learning of a new information technology but also contributes to the maintenance and modification of the technical artifact, thus creating values for the technical system. The notion of value creation from system support and maintenance was echoed in a prior study of call center (Huang et al., 2007) that reveals how a call center can generate value from its commodity process. Moreover, our study moves beyond the social-technical aspect in IS deployment by examining the characteristics of the network in which both IS professionals and end-users are embedded and engaged.

6. Limitations and Future Research

As this study focused on IS use and support of a large organization with its unique organizational context, the generalizability of the research findings is likely to be constrained by the type of organizational structure. However, given the study's focus on user-system engagement and on the IS support community for a new IS system, the findings could be tentatively applied to the context of other types of information systems and to knowledge-intensive communities. In spite of the limitations, this study suggests that organizations should value knowledge accumulated and residing in the network of IS professionals and end-users when evaluating the returns on their IT investments, and consider the factors of network characteristics when managing their IT resources.

Due to data limitations, we only controlled for the time (longitudinal) effects on productivity. There could be other confounding factors such as support personnel's past work experiences and complexity of the ticketed problems which could also affect support personnel's productivity. We didn't control for them due to the lack of accessibility to those data. Furthermore, this study only examines two network measures. Future research can examine more network characteristics and their effects on knowledge transfer in the IS support community. It will also be interesting to examine the relative importance of each network characteristics for facilitating the key factors for knowledge transfer in the IS support community in the future.

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