How Does Collaborative Group Technology influence Social Network Structure?

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Abstract

The relationship between technology and elements of the formal organization structure has long been of interest to information systems and organization researchers. A less-studied issue is how technology may also influence the informal *social network structure. This research examines how various types of technological expertise relate to an individual's network centrality in the project teams of 99 MBA, MISM, and MAIS students at a large public university. To further understand this relationship, the project task was varied in terms of "uncertainty" and the formal group structures in terms of departmentation. Results indicate that individuals who are proficient with various types of technologies tend to be more central in their class advice network. However, this relationship depends on both the level of task uncertainty and group departmentation. Implications are drawn for practice and research.*

1. Introduction

Early modern organizational theorists proposed that technology will help to shape organizational structures [21, 31, 35, 38]. However, technology was just one variable in addition to the organization strategy [25] and task environment [1] which determines the most appropriate form an organization should take in order to survive. The Contingency Theory of organizations posits that as any one of those variables (technology, environment, and strategy) changes, so should the organization since there is no one best way structure for survival [9, 12].

Since then, researchers have extended this deterministic view, labeled as the "technological imperative" [24], to include the role of human agency [7, 29]. For example, Adaptive Structuration Theory posits that structure is not determined by technology, but rather, is the result of a recursive relationship between technology design and human interaction [11]. Others have identified particular examples of human agency as sources of inconsistency in research based in technological determinism [20, 32]. Regardless of the causal structure or role of human agency, most researchers agree that significant relationships between technology and structure exist.

Burkhardt and Brass [8] took a unique perspective on this relationship when they studied how changes in technology influenced the structure of social networks – a type of *informal* structure as opposed to the *formal* structure variables typically studied such as centralization, departmentation, formalization, etc. [1, 26, 35]. In this case, structural changes are not the result of conscious management decisions in order to "fit" with the technology. Rather, changes to the social network structure happen gradually and informally as individuals find new sources of advice, knowledge, and information or drop existing sources. They found that over time, individuals who adopt technology sooner rather than later become more central in knowledge networks and are perceived to have more power and influence in the activities of the organization [8].

Thompson [35] was one of the earliest to cite the influence of technology on coordination structures. He theorized that the formal coordination structures created through group departmentation are formed depending on the nature of the technology used to accomplish organizational objectives. However, the formal group structures do not always provide for the level of coordination required by the task environment. Therefore, informal coordination patterns which exist to compensate for the "mutual adjustment" required by the task. Social network analysis is an effective way to measure the actual coordination structures taking place within an organization and test relevant hypotheses [10]. Although the body of literature on social network theory is well-established [6, 17, 30], few have used social network analyses (SNA) to study the technology/structure relationship from an organization theory perspective [cf 35].

This research seeks to help fill that gap by exploring how various types of technology use are related to the advice network centrality of MBA, MISM, and MAIS students in two graduate-level courses over time. It extends the work of Burkhardt and Brass [8] by including the moderating effect of uncertainty which, according to the Information Processing perspective [36], determines the level of coordination required by the task. However, rather than changing the technology use over time, we change the project teams structures. So the contingency model uses changes in formal structure as an occasion for *in*formal re-structuring. Although several social network researchers have studied how elements of the formal structure precondition the network structure, none (to our knowledge) have empirically tested the effects of group departmentation. In summary, we are testing how the relationship between individual technology use and network centrality is affected by a change in group structure in more- and less-certain task environments.

The following section reviews the relevant literature from Social Network Theory and Organization Theory and outlines our hypotheses. The next section describes the methodology and setting. Next, we review the results of the study. Finally, we discuss the implications and limitations of the results and conclude.

2. Literature Review

Much of the literature on Network Theory is focused on discovering and measuring the antecedents and consequences of network structures. Since it has already been established that centrality in the advice network of MBA students leads to better attitudes and performance [3], the current study of business school graduate students is focused on understanding how technological expertise and group structure lead to network centrality. Centrality is measured in variety of ways, but basically indicates how well-connected an individual is within a network [13].

Burkhardt and Brass's [8] study of technology and network structure was one of few at that time which modeled the changes in network structure over time. They discovered that if individuals who were already central in the advice network were early adopters of the new technology, then their centrality did not change. However, if individuals who were not very central decided to adopt the technology early, they would become *more* central as a result. Because of the longitudinal nature of their experiment, Burkhardt and Brass [8] were able to establish technological expertise as a clear antecedent to centrality.

Therefore, our first hypothesis is a confirmation of Burkhardt and Brass's [8] finding in an educational context using a wider and different variety of technology than the enterprise system they studied:

H1: Individual technology expertise is positively related to advice network centrality in the classroom.

2.1. Uncertainty and Social Networks

The theoretical logic underlying H1 is that changes in technology induce uncertainty [8]. Changing technology means changing the process an organization uses to turn inputs into outputs which can increase uncertainty [14]. According to the Information Processing (IP) Perspective, organizations achieve a performance-maximizing "fit" when the IP demands from the uncertainty in their task environment are met by the IP capabilities of their technology and structure [15, 36]. If technology is changed, then a certain amount of time is required for people to familiarize themselves with it and learn to use it to meet their IP demands.

Essentially, an increase in uncertainty results in an increase in communication [18, 37]. In a university environment, students encounter uncertainty when they begin a new course. If that course requires (or could benefit from) the use of a technology which an individual is not familiar with, they will seek out knowledge and advice about the technology from those who have that particular expertise.

The type of technological knowledge individuals seek may depend on the amount and type of uncertainty in the classroom. Several organization theorists have generated simple taxonomies for technology. Thompson [35] distinguishes between long-linked, mediating, and intensive technologies. Woodward [38] discerns between small-batch, large-batch, and continuous production technologies. However, these production-based taxonomies do not fit well for the classroom context. Huber [16] makes the distinction between simpler communication technologies and advanced decision-aiding technologies. His argument was that the newer, advanced technologies may have a different effect on organization structure than the simpler communication technologies that had already been adopted by most people. We believe a similar distinction can be made about the technologies used by graduate students. Most are familiar with traditional office productivity technologies for word processing, spreadsheets, email communication, web browsing and search, etc. However, far less may be familiar with some of the more advanced technologies used to support collaborative group work in the form of internet videoconferencing, blogs, wikis, file sharing, and group support systems. Therefore, we make a simple distinction between simple "office" technologies and advanced collaborative group technologies.

When task uncertainty is high, the individuals with the most expertise in collaborative group technologies which offer greater information processing will be relatively more central. When task uncertainty is low, individuals with the most expertise in "office" technologies will be relatively more central. Therefore, we make the following hypotheses:

> *H2a: In conditions of high task uncertainty, individual expertise in collaborative group technology will be relatively more related to classroom advice network centrality than expertise in "office" technology.*

> *H2b: In conditions of low task uncertainty, individual expertise in "office" technology will be relatively more related to classroom advice network centrality than expertise in collaborative group technology.*

2.2. Group Structure and Social Networks

Several studies of organization structural antecedents to social networks exist. For example, people who work or reside near each other in physical proximity tend to form knowledge sharing relationships [4] which are stronger and more stable [27]. Also, individuals with higher rank tend to become more central in advice and friendship networks [22]. However, there is little research, if any, concerning the effects of departmentation – one of the central variables in Organization Theory [35].

Departmentation is one of the critical dimensions of organizational structure research [9]. It refers to how positions and roles are grouped in order to handle the internal coordination requirements of the technological process [35]. Most commonly, the departmentation is referred to as being *functional* or *divisional*. Functional groups are based on performing similar functions or tasks. All members of the functional team perform the same or similar tasks. Their activities must be coordinated with other groups to accomplish an overall objective. Divisional groups perform all of the needed tasks for a particular product or geographic region. Consequently, the tasks performed by the team members are varied.

These two forms of group structure have important implications for how social networks may form. For example, because team members in functional groups perform the same task, they will benefit more from knowledge and advice sharing. On the other hand, members of divisional groups will not have as much need or benefit from internal knowledge sharing. They may need to coordinate with other group members to complete the overall objective, but they will not be able to seek advice concerning their own task from others who perform different tasks from them. So, the relationship between technological expertise and network centrality is also moderated by group departmentation (See Figure 1):

> *H3: The relationship between individual technological expertise and advice network centrality is relatively stronger in functionally structured groups than in divisionally structured groups.*

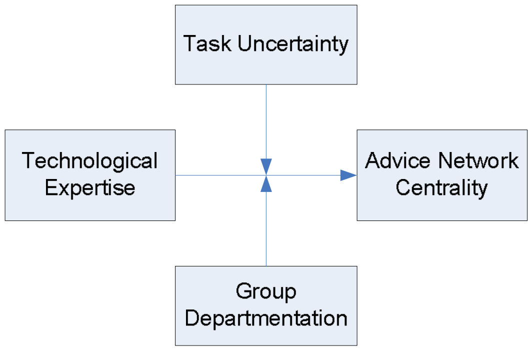

Figure 1: Theoretical Model

According to Structural Contingency Theory, organizations change their structure to fit their environment. Along these lines, Moon et al. [28] made an interesting discovery concerning changes in group departmentation. They found that the consequences of changes to group structure depend on the nature and direction of the change. Specifically, they found that a change from functional to divisional might be more advantageous in terms to knowledge sharing than a change from divisional to functional. Their reasoning is based on Entrainment Theory [2] which posits that the norms and habits in a social system persist (or become "entrained") over time even after their operational value is gone. The implication is that the good knowledge sharing habits of functional groups may carry over after a switch to a divisional structure for a certain amount of time. Alternatively, divisional groups which change to functional structures may experience a dip in performance until they develop good knowledge sharing cultures. This phenomenon was termed Asymmetric Adaptability [28].

Based on this, class project teams that make the divisional-to-functional (D2F) switch should develop improved advice patterns and the relationship between technological expertise and centrality will strengthen. On the other hand, teams which make the functional-to-divisional (F2D) switch will experience little or no decrease in the need for technological expertise sharing. Therefore, the strength of the relationship between expertise and network centrality should remain the same or decrease only slightly.

H4a: When group structures change from divisional to functional, the strength of the relationship between individual technological expertise and advice network centrality increases.

H4b: When group structures change from functional to divisional, the strength of the relationship between individual technological expertise and advice network centrality remains the same initially, but may decrease over time.

3. Methodology

3.1. Sample and Demographics

The test these hypotheses, a social network analysis was performed with graduate students in the business school of a large public university in the western United States. Specifically, five sections of two graduate level information systems courses were selected with 28 to 35 students in each course for a total of 99 students. Sixty of those 99 were enrolled in both courses. Course 1 had 70 students between two sections and course 2 had 89 students among three sections. Of those who reported, 56 students were in the Master of Information Systems Management program, 24 were in the Master of Accounting Information Systems program, and 10 were in the Master of Business Administration program. One third of the students were female and the average age was 33. While the majority of students were U.S. citizens, many came from other countries including Vietnam, China, Japan, Mexico, Trinidad, Tanzania, Zambia, Serbia, India, Taiwan, Pakistan, Australia, England, Israel, and Korea.

3.2. Measures

3.2.1. Networks and Network Centrality. Networks were measured in the typical fashion [3, 33] by asking, "Who do you go to for knowledge or advice for…" and providing a list of names of every individual in the class. Consequently, a separate network was measured for each section of each course. Response rates ranged from 80 to 100 percent for each network measurement.

In-degree centrality was measured by using Stephenson and Zelen's [34] closeness index as used in Baldwin's [3] study of MBA teams. In-degree refers to counting only those relations with an individual specified by other individuals, thereby removing any self-reporting bias. The closeness index denotes the degree to which an individual is close to all other actors in the network whether directly or indirectly (i.e. friend of a friend of a friend).

3.2.2. Task Uncertainty. Task uncertainty varied between the two courses in terms of the group projects assigned by the instructors. The group project for course 2 was a "typical" business-oriented written report and presentation to be completed by teams for four to five members. The only technology required by the project was basic office productivity software for word processing, presentations, web research, and email communication. Dividing work and roles among team members was a fairly simple task. Basically, this project was relatively low in task uncertainty.

On the other hand, the group project for course 1 was unique. The students were required to develop a Reusable Learning Object (RLO). RLOs are web-based interactive "chunks" of independent e-learning modules [23]. RLOs consist of multiple sub-objects which are grouped together. The sub-objects might consist of Flash demonstrations, "wizards," and tutorials. Although it is possible that some students had used RLOs in the past, it is far less likely that any would have had experience creating one. Compared to the written paper and group presentation of course 2, we expect this project to have greater uncertainty.

3.2.3. Group Departmentation. Two group projects were assigned in both courses. One was due at the midpoint of the semester and the other was due at the semester's end. Group departmentation was manipulated by the instructors by changing the group makeup and nature of the assignments from the first project to the second.

In course 1, the first group project was to create an entire RLO on one particular topic. Although the students could divide up the work any way they pleased, they were at least working on the same topic and could benefit from helping each other. This represents a functional structure. After this project was submitted, the students were rearranged into new groups and were asked to bring their knowledge and experience creating sub-objects from their prior group into the new one. In this situation, each student in the group came in with a different skill set and could contribute only with the experience they had. The result was that each student worked on their own sub-object(s). This represents a divisional structure relative to the first project.

In course 2, the first group project was a report and presentation on the critical issues and steps involved in project management. The students had learned about and were exposed to a wide variety of topics. In most cases, the groups assigned particular topics to particular students representing a divisional structure. The second group project involved selecting one particular project management issue and forming a new group to further explore and study that single issue. The deliverable was another written paper on their findings. Because all students were working on the same topic, this project group represented a functional structure relative to the first group.

In summary, the two sections of course 1 made a F2D switch, whereas the three sections of course 2 made a D2F switch. Although it was not possible to directly enforce "functional" and "divisional" roles in every group, the requirements were developed to every extent possible to encourage similar roles for groups that should be functional and segregated roles for groups that should be divisional.

Network surveys were administered for each project of each section of each course. In other words, the survey question was, "Who did you go to for knowledge and advice concerning project 1 in the course CIS…?" Each network survey was administered in the course section they were referring to and immediately after the group projects had been submitted. In total, 10 networks were measured – two for each of the five sections.

3.2.4 Technological Expertise. Measuring technological expertise required a simple survey with a list of technologies. Each student was asked (1) how much they had used each technology, and (2) what their level of expertise was with that technology. The responses were given on a Likert-type scale ranging from one to five with one being "Never used" or "Not skilled" and five being "Often used" or "Very skilled."

The list of technologies itself was developed by a pre-survey of the students which asked what types of technologies they had been using during that semester. The resulting list included email, web searching, instant messaging, online discussion boards, electronic portfolios (e.g. Blackboard), video conferencing, audio conferencing, word processing software, spreadsheet software, presentation software, Google Docs & Spreadsheets, blogs, wikis, and ThinkTank™. ThinkTank™ is an advanced collaborative group support tool created in juncture with GroupSystems™. It allows them to write, outline, brainstorm, vote, etc. electronically, asymmetrically, and in a distributed Internet environment. Because the students were likely to have had no experience with ThinkTank™, they were given a classroom demonstration and training session at the beginning of the semester.

4. Experimental Results

4.1. Technological Expertise

In order to appropriately categorize each of the technologies into either the office productivity or collaborative group support categories, an exploratory factor analysis was performed on the student's responses (95 percent response rate). Using Varimax rotation and Principle Axis Factoring as the extraction method, they demonstrated convergent and discriminant validity into the two technology types (See Table 1). The technologies of instant messaging, discussion boards, electronic portfolios, and audio conferencing did not load well on either factor and were removed from the analysis. Of the ten remaining technologies, five loaded on the office factor and five on the group factor. Cronbach's Alpha was computed for the technologies in each factor. Both factors demonstrated reliability above .80 (α = .86 for office, α = .83 for group). As expected, the technologies loading on the office factor were the simpler, more familiar technologies needed for basic tasks like those in course 2. These included email, web searching, word processing, spreadsheets, and presentation software. The technologies which loaded on the group factor were more advanced and are used to support greater amounts of group communication and coordination. These included video conferencing, Google Docs & Spreadsheets, blogging, wikis, and ThinkTank™.

Table 1: Rotated Factor Matrix for Technologies

Technologies	Office	Group
Email	**0.76**	0.19
Web Searching	**0.70**	0.25
Word Processing	**0.90**	0.12
Spreadsheets	**0.81**	0.13
Presentations	**0.78**	0.08
Video Conferencing	0.14	**0.70**
Google Docs & Spreadsheets	0.32	**0.57**
Blogging	0.28	**0.72**
Wikis	0.08	**0.69**
ThinkTank	-0.01	**0.77**

Note: Principle Axis Factoring with Varimax rotation

4.2. Advice Network Centrality

Table 2 reports descriptive statistics and correlations for each included variable. To measure the relationship between technological expertise and advice network centrality in varying conditions of uncertainty and group departmentation, four multiple regression models were developed and reported in Table 3.

Table 2: Descriptive Statistics and Correlations

Variable	Mean	Std. Dev.	1	2	3	4	5
Office Skills	4.25	1.01					
Group Skills	1.95	1.07	0.55**				
Course 1 Project 1	13.10	2.79	0.13	0.34**			
Course 1 Project 2	8.76	2.42	0.01	0.20	0.14		
Course 2 Project 1	13.94	3.24	-0.11	0.05	0.59**	0.22*	
Course 2 Project 2	9.57	3.68	0.22*	-0.06	-0.53**	0.24*	-.44**

Note: ** Correlation is significant at the $p < 0.05$ level;
* Correlation is significant at the $p < 0.01$ level

Table 3: Coefficients and Std. Err. For Regressions

Variables		Models 1	2	3	4
Office Technology Expertise	b	-0.188	-0.322	-0.548	1.176**
	s.e.	0.454	0.345	0.364	0.435
Group Technology Expertise	b	0.889**	0.494†	0.407	-0.769
	s.e.	0.334	0.260	0.344	0.411
R^2		0.114	0.053	0.030	0.086
F		4.128*	1.797	1.243	3.807*
d.f.		68	66	83	83

Note: ** Significant at $p < .01$; * $p < .05$; † $p <= .06$

According to the four regression models, the support for H1 was mixed, but positive overall. Essentially, technological expertise was indeed significantly related to centrality in advice networks. However, the relationship depended on task uncertainty and group departmentation.

Model 1 displays the regression results for project 1 in course 1 (functional group, high uncertainty). In support of H2a, expertise with the advanced collaborative group technology was significantly related to network centrality whereas office technology expertise was not.

Model 2 displays the results for the regression of technology on network centrality after the students in course 1 made the switch to a divisional structure (course 1 project 2). As predicted by H4b, the relationship between group technology expertise and network centrality remained significant per Entrainment Theory with a F2D switch. However, the significance level had dropped to a marginal level (p = .06) by this time.

Model 3 gives the regression results for project 1 in course 2 (divisional group, low uncertainty). Contrary to H2b, neither office technology skills, nor group technology skills, were significantly related to network centrality. However, that result changed in Model 4. When the students made the D2F switch for project 2, office technology expertise did become a significant predictor of advice network centrality, thus confirming H4a.

6. Discussion

The results of this study offer support for the theory that technology is related structure [31, 35, 38]. In this case, we applied this relationship in the context of informal network structures rather than formal coordination structures. However, to expand on the work of Burkhardt and Brass [8], we included the effects of changing the formal group departmentation and the moderating influence of task uncertainty – both of which are critical variables in modern organizational theory. Table 4 summarizes our hypotheses and results.

Table 4: Hypotheses and Results

H1: Technology expertise is positively related to centrality.	Supported
H2a: In high task uncertainty, group technology expertise is more related to centrality than office tech. expertise.	Supported
H2b: In low task uncertainty, office technology expertise is more related to centrality than group tech. expertise.	Partial support
H3: The technology/centrality relationship is stronger in functional groups than divisional groups.	Supported
H4a: When groups make a D2F switch, the technology/centrality relationship strength increases.	Supported
H4b: When groups make a F2D switch, the technology/centrality relationship strength remains the same initially, but decreases over time.	Supported

Although model 3 did not find a significant relationship between technological expertise and advice network centrality, model 4 did when the groups made a D2F switch. Overall, we believe that H1 is supported. However, the relationship does depend on some moderators. H2a was supported in that group technology expertise was more important in conditions of high task uncertainty. H2b received partial support. Although office technology was a better indicator of centrality in environments of low task uncertainty, this relationship only held in a functional group structure when group members had greater incentive to share knowledge.

H3 was supported in that both functional groups demonstrated a stronger technology/centrality relationship than their divisional counterparts. Finally, both H4a and H4b were also supported. When groups made the D2F switch, the importance of technological expertise increased because there was greater value in knowledge and advice sharing. However, when groups made the F2D shift, the culture of advice sharing did not entirely disappear as in the divisional group in the D2F pattern.

6.1. Limitations

As with most experimental research, this work comes with limitations and boundaries which suggest fruitful areas for future research. First, the academic context of this study allows certain direct implications to be drawn for business school graduate student groups. However, using student subjects for the manipulation of task uncertainty and divisional and functional groups may not extend well to some organizations. Future research should explore structural and environmental variables like these in actual organizations.

Also, there are possibly some confounding influences from measuring separate networks which are likely to be highly related. For example, since many students were registered in both courses, the networks of one course are likely to be influenced by the networks of the other course. And the networks based on project 1 are likely to influence the networks of project 2. This problem is exemplary of those inherent in field research. We are limited by the context of the environment we study. However, this scenario does provide a certain level or realism in a business environment since virtually all organization sub-networks are likely to be influenced by other related sub-networks. In addition, certain carry-over effects from one network to another are necessary to study certain effects such as Asymetric Adaptation.

6.2. Implications

6.2.1. For Research. This work has several implications for organizational and social network research. First is supports the notion that technology is related to structure. However, by examining this relationship in terms of the informal network structure and examining the effects of a range of particular technologies, it provides a more detailed understanding. In addition, is supports the theoretical influence of uncertainty from the IP perspective [36] and demonstrates actual changes in coordination patterns to achieve "fit" between IP capabilities and demands.

For the social network literature, it adds a study which measures the effect of changing group departmentation on network structure. This is clearly an important variable which has received little attention from prior literature. We hope that it generates further interest in the relationship between elements of the formal organization structure and the informal network structure.

6.2.2. For Practice. For managers currently using SNA as a tool for organization design, promotions, or task assignment, this research adds some critical dimensions to consider when making decisions. For example, technological skills play an important role in determining the network structure. Since network structure has been demonstrated to have significant impacts on group and individual performance [3, 5, 33], it is important to consider all of the potential antecedents.

This research should be of particular interest to organizations employing project-based cross-functional groups. For example, software development is often a project-based task [e.g. 19]. In Keith et al.'s case study [19], software engineers belonged to functional "home" groups which were based on performing certain types of development functions. As projects were funneled into the software development unit, they were then assigned to a project manager (PM) who selected individuals from various functional groups to join a temporary project team which was divisionally structured. Basically, group members were constantly switching from functional to divisional groups and back again. If the PM uses SNA to help derive project teams, then it would be important to consider the effects of group departmentation and the direction of changes network structure.

7. Conclusion

In conclusion, we found that technological expertise is an important indicator of centrality in the social networks of business school graduate students. The relationship depends, however, on the type of expertise and uncertainty of the task. Specifically, highly uncertain tasks place individuals with expertise in advanced group support technologies in central network position whereas tasks which have less uncertainty place individuals with basic office technological expertise in central positions. In addition, the relationship between technological expertise and network centrality is affected by the departmentation of the project group. Functional groups tend to foster the expertise/centrality relationship more than divisional groups. We hope that this work will foster interest in the use of SNAs to study the relationship between technology and organizational coordination structures.

8. References

[1] H. E. Aldrich, Organizations and Environments, Prentice Hall, New Jersey, 1979.

[2] D. Ancona and C. Chong, Entrainment: Pace, Cycle, and Rhythm in Organizational Behavior. In L. L. Cummings & B. M. Staw (Eds.), Research in Organizational Behavior, vol. 18: 251–284. Greenwich, CT: JAI Press, 1996.

[3] T. T. Baldwin, M. D. Bedell, J. L. Johnson, "The Social Fabric of a Team-Based M.B.A. Program: Network Effects on Student Satisfaction and Performance," *Academy of Management Journal*, 40 (6), 1997, pp. 1369-1397.

[4] S. P. Borgatti and R. Cross, "A Relational View of Information Seeking and Learning in Social Networks," *Management Science*, 49, 2003, pp. 432–445.

[5] D. J. Brass, "Structural Relationships, Job Characteristics, and Worker Satisfaction and Performance," *Administrative Science Quarterly*, 26, 1981, pp. 331-348.

[6] D. J. Brass, J. Galaskiewicz, H. R. Greve, W. Tsai, "Taking Stock of Networks and Organizations: A Multilevel Perspective," *Academy of Management Journal*, 47 (6), 2004, pp. 795-817.

[7] M. Boudreau and D. Robey, "Enacting Integrated Information Technology: A Human Agency Perspective," *Organization Science*, 16 (1), 2005, pp. 3-18.

[8] M. E. Burkhardt and D. J. Brass, "Changing Patterns or Patterns of Change: The Effects of a Change in Technology on Social Network Structure and Power," *Administrative Science Quarterly*, 35 (1), 1990, pp. 104-127.

[9] T. Burns and G. M. Stalker, The Management of Innovation, Tavistock, London, 1961.

[10] R. Cross and A. Parker, The Hidden Power of Social Networks, Harvard Business School Press, Boston, 2004.

[11] G. DeSanctis and M. S. Poole, "Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory," *Organization Science*, 5 (2), 1994, pp. 121-147.

[12] L. Donaldson, The Contingency Theory of Organizations, Sage Publications, London, 2001.

[13] L. C. Freeman, "Centrality in Social Networks: Conceptual Clarification," *Social Networks*, 1, 1978/79, pp. 215-239.

[14] L. W. Fry, "Technology-Structure Research: Three Critical Issues," *Academy of Management Journal*, 25 (3), 1982, pp. 532-552.

[15] J. R. Galbraith, Organization Design, Addison-Wesley, Reading, 1977.

[16] G. P. Huber, "A Theory of the Effects of Advanced Information Technologies on Organizational Design, Intelligence, and Decision Making," *Academy of Management Review*, 15 (1), 1990, pp. 47-71.

[17] N. Katz, D. Lazer, H. Arrow, and N. Contractor, "Network Theory and Small Groups," *Small Group Research*, 35 (3), 2004, pp. 307-332.

[18] R. Katz and M. Tushman, "Communication Patterns, Project Performance, and Task Characteristics: An Empirical Evaluation and Integration in an R&D Setting," *Organizational Behavior and Human Performance*, 23, 1979, pp. 139-162.

[19] M. Keith, H. Demirkan, and M. Goul, "Coordination Network Analysis: A Research Framework for Studying the Organizational Impacts of Service-Orientation in Business Intelligence," *40th Annual Hawaii International Conference on System Sciences, HICSS 2007*, pp. 215b.

[20] R. Kling and W. Scacchi, "The Web of Computing: Computer Technology as Social Organization," *Advances in Computers*, 21, 1982, pp. 1-90.

[21] H. J. Leavitt and T. L. Whisler, "Management in the 1980's," *Harvard Business Review*, 36, 1958, pp. 41-48.

[22] J. R. Lincoln and J. Miller, "Work and Friendship Ties in Organizations: A Comparative Analysis of Relational Networks," *Administrative Science Quarterly*, 24 (2), 1979, pp. 181–199.

[23] Q. Liu, Z. Yang, K. Yan, and D. Wu, "Reusable Learning Objects and Its Strategies for e-Learning," *Lecture Notes in Computer Science*, 3143, 2004, pp. 386-392.

[24] M. L. Markus and D. Robey, "Information Technology and Organizational Change: Causal Structure in Theory and Research," *Management Science*, 34 (5), 1988, pp. 583-598.

[25] R. E. Miles and C. C. Snow, Organizational Strategy, Structure, and Process, McGraw-Hill Book Co., New York, 1978.

[26] H. Mintzberg, The Structuring of Organizations, Prentice Hall, Englewood Cliffs, NJ, 1979.

[27] P. R. Monge and E. M. Eisenberg, Emergent Communication Networks, In F. M. Jablin, L. L. Putnam, K. H. Roberts, & L. W. Porter (Eds.), Handbook of Organizational Communication: An Interdisciplinary Perspective, pp. 304–342, Sage, Newbury Park.

[28] H. Moon, J. R. Hollenbeck, S. E. Humphrey, D. R. Ilgen, B. West, A. P. J. Ellis, C. O. L. H. Porter, "Asymmetric Adaptability: Dynamic Team Structures As One-Way Streets," *Academy of Management Journal*, 47 (5), 2004, pp. 681-695.

[29] W. J. Orlikowski, "The Duality of Technology: Rethinking the Concept of Technology in Organizations," *Organization Science*, 3 (3), 1992, pp. 398-427.

[30] A. Parkhe, S. Wasserman, D. A. Ralston, "New Frontiers in Network Theory Development," *Academy of Management Review*, 31 (3), 2006, pp. 560-568.

[31] C. Perrow, "A Framework for the Comparative Analysis of Organizations," *American Sociological Review*, 32, 1967, pp. 195-208.

[32] D. Robey and M. Boudreau, "Accounting for the Contradictory Organizational Consequences of Information Technology: Theoretical Directions and Methodological Implications," *Information Systems Research*, 10 (2), 1999, pp. 167-185.

[33] R. T. Sparrowe, R. C. Liden, S. J. Wayne, and M. L. Kraimer, "Social Networks and the Performance of Individuals and Groups," *Academy of Management Journal*, 44 (2), 2001, pp. 316-325.

[34] K. Stephenson and M. Zelen, "Rethinking Centrality," *Social Networks*, 11, 1989, pp. 1-37.

[35] J. D. Thompson, Organizations in Action: Social Science Bases of Administrative Theory, McGraw-Hill Inc., New York, 1967.

[36] M. L. Tushman and D. A. Nadler, "Information Processing as an Integrating Concept in Organizational Design," *Academy of Management Review*, 3 (3), 1978, pp. 613-624.

[37] A. Van de Ven, A. Delbecq, and R. J. Koenig, "Determinants of Coordination Modes Within Organizations," *American Sociological Review*, 41, 1976, pp. 322-338.

[38] J. Woodward, Industrial Organization: Theory and Practice, Oxford University Press, New York, 1965.