

Knowledge Management and Organizational Adaptation Effectiveness: An Empirical Study

Kuei-Hsien Niu

Professor

College of Business Administration
California State University Sacramento
6000 J St. Sacramento CA 95819

&

Hui Li

Associate Professor

College of Economics and Social Science
Northwestern Polytechnic University, China

Abstract

Knowledge management has become increasingly important in today's business world. To better adapt to rapid environmental changes, organizations implement knowledge management to avoid repetition of mistakes, shorten the period of problem solving, and stimulate innovations. This study investigates the stages of knowledge management: obtaining, organizing, and applying, that affect organizational adaptiveness. Using the data collected for self-administered survey, the results show the three major stages of knowledge management have significant influences on organizational adaptiveness.

Keywords: knowledge management, organizational adaptiveness, adaptation effectiveness

Introduction

Twenty-first century has been recognized as the knowledge-based economic era. The most distinctive feature of the knowledge-based economy is that knowledge has become the strategically significant resource organizations possess to sustain competitive advantage (DeGeus, 1988). Natural resources have become less important in today's knowledge explosion era. Organizations must survive and succeed in the midst of dramatic and rapid environmental changes. Since organizational inputs and outputs are associated with various kinds of knowledgeable resources, obtaining, organizing, and applying knowledge become the main parts of organizations' activities. Theories and tools are needed to manage and create sources of valuable knowledge and to develop organizational knowledge bases to create organizations' innovativeness and sustain the competitive advantage (Corno, Reinmoeller, and Nonaka, 1999; Marshall, 1997).

As economies depend increasingly on obtaining, disseminating, and the use/reuse of knowledge, organizations begin to emphasize the subjects of knowledge management. Knowledge management is considered a process, which encompasses creating, capturing, and applying knowledge to achieve organizations' objectives (Bock, 2000). The purpose of knowledge management is to establish an environment that allows organizations to leverage knowledgeable assets (Trepper, 2000).

By leveraging knowledgeable assets, organizations can increase profits, reduce costs, and enhance research and development (R&D) capacity (DeTienne and Jackson, 2001; Drucker, 1994). Moreover, knowledge management contributes significantly to the accumulations and articulations of organization specific skills and technological know-how as well as to streamline organizational decision-making process (Cohen and Levinthal, 1990; March and Simon 1958; Nelson and Winter, 1982). Hence, by emphasizing knowledge management, organizations not only can enhance competence over time but also can lower the risk and sustain competitive advantage (Hannan and Freeman, 1984, 1989; Levinthal, 1991; Porter, 1985).

To survive in Schumpeterian economy, organizations need to establish the ability to adapt to the increasing complexity and high-velocity change (Brown and Eisenhardt, 1998; McGrath, 2001; Schumpeter, 1950). Organizational adaptation requires the creation of variety that can be facilitated by learning (Levinthal, 1991; March, 1991; McGrath, 2001). Knowledge transfer and creation serve as the vehicle to organizations' ability to innovate and tighter cooperation (Kogut and Zander, 1992; Tsai and Ghoshal, 1998). Supported by March (1991) and Levinthal (1991), organizational knowledge and learning are both influential to organizations' adaptation to the environmental changes. In highly novel settings of environment, organizations need to gain knowledge for improving what they have already known, which is competency enhancement, as well as for innovating (Burns and Stalker, 1961). Therefore, organizations that prove to have superior capabilities to manage knowledge will be more capable of adapting to environmental changes with high uncertainty and complexity (McGrath, 2001). However, organizational learning is in a dynamic context and considered the early stage of knowledge management (Hannan and Freeman, 1984, Levitt and March, 1988). It leaves the open question of whether the other stages of knowledge management process are influential to organizations' adaptiveness. The term "adaptiveness" in the present study refers to an organization's ability to adapt to environmental changes.

We seek to contribute to the knowledge management and organizational adaptiveness by linking the two streams of research that have not been connected previously. The purpose of this study is to explore how knowledge management affects organizational adaptiveness. A framework synthesized from a review of literature is constructed and seven distinct hypotheses of knowledge management are developed. Even each knowledge stage is examined individually, literatures suggest that they should be viewed as a systematic process. In practice, the findings present that major stages of knowledge management indeed influence organizational adaptiveness. This study begins with a theoretical context and presents an outline of the conceptual framework and hypotheses that anchor this paper. Data were collected via survey questionnaires. In the end, we present the results of analyses, limitations, and implications for both theory and practice.

THEORETICAL BACKGROUND

Organizational Adaptiveness

Research on organizational theory has been dominated by two paradigms. One line of research has emphasized on organizational adaptation to environmental contingencies (Cyert and March, 1963; Lawrence and Lorsch, 1967) while Hannan and Freeman (1977, 1984) proposed the population ecology paradigm arguing that organizational adaptation is often too slow to successfully react to environmental changes. The organizational adaptation perspective stems from classic contingency theory, resource dependency, and transaction cost theory which argues that there are multiple ways for organizational design and organizations must adapt to environmental changes in order to survive. In contrast, the population ecologists propose that organizational forms with the best fit to environmental characteristics are selected and proliferated. A variety of forms is created in natural selection, some are selected for better fit, and the organizational form is retained through reproduction and duplication. Researchers in this domain contend that organizations usually do not change or adapt but are replaced by organizations with forms and structures that have better fit to the environment.

Some other researchers do not consider conflict between organizational adaptation and environmental selection perspectives. Rather, the two aspects are complementary (Astley and Van de Ven, 1983; Levinthal, 1991; Scott, 1987). Scott (1987) argues that organizational adaptation perspective is useful in examining more peripheral features, larger organizations and shorter time periods while selection process is a complement in explaining the core features of organizations, smaller organizations and looking over longer periods. The present study argues that organizational forms which best fit the environment is a consequence after multiple adaptive attempts. Environmental changes are unpredictable and organizations need to maintain the flexibility and capability to adapt to the environmental contingencies in a short run. It is essential for organizations to have an effective adaptive system in an uncertain environment.

A central concern of organizational adaptive system is the balance between the exploration of new possibilities and exploitation of existing certainties (Holland, 1975; Kuran, 1988; March, 1991; Schumpeter, 1934). Intelligent adaptation, also known as learning (March, 1991; Levinthal, 1991), acts as a means to balance organizational exploration and exploitation and to reconcile adaptation and selection perspectives (March, 1991; Levinthal, 1991). March (1991) models the development and articulation of organizational knowledge and suggests that learning constitutes intelligent adaptation, which would lead to the balance between organizational exploration and exploitation. Effective selection among forms, norms, and routines in turbulent environment is equally important to the generation of new alternative practices for organizations' survival. Knowledge accumulation and development within an organization contributes significantly to both exploratory and exploitative learning and in turn, facilitates organizations to adapt to the environment in both short run and long run. More specifically, effective knowledge management helps organizations enhance innovativeness as well as organizational competency.

Knowledge Management

Knowledge management theory is associated with accessing and using of all information within an institution, which facilitates individuals to apply appropriate information and knowledge to what they already know, to create new knowledge (Marshall, 1997; Pfeffer and Sutton, 2000). The major concern is the creation of structures that combines the most advanced elements of information resources, indispensable input of human response, and decision-making (Raisinghani, 2000). Wilson and Asay (1999) define knowledge management as providing rapid access to information and expertise throughout whole systems as needed to enhance individual and organizational learning and performance. Organizations need to develop the ability to leverage existing knowledge and create new knowledge that favorably positions organizations themselves in the chosen markets to become competitive (Gold, Malhotra, and Segars, 2001).

Extensive reviews of knowledge management literature exist (Cohen and Levinthal, 1990; Crossan *et al.*, 1999; Levitt and March, 1988; Tsai, 2001; Vera and Crossan, 2003, 2004). Many researchers agree that the knowledge management field lacks integrative works and empirical studies (Simon, 1991; Vera and Crossan, 2004; Weick, 1991). A recent theoretical framework, Crossan *et al.*'s (1999) 4I model of organizational learning, proposes a coherent conceptualization of knowledge management. They view organizational learning as part of organizational knowledge management process that can be categorized into new learning and improving what has been learned. The perspective of new learning and improving what has been learned goes line with March's (1991) managing knowledgeable novelty and continuity perspective. Crossan *et al.* (1999) further indicate that organizational learning could happen in individual level, group level and organization level. The perceived knowledge from the same compilation of information can differ greatly, not only in quality but also in applicability because individuals, groups, and organizations have different mental modes (Senge, 1994). Crossan *et al.* (1999) argue that each level could obtain new knowledge, transfer new/existing knowledge, or obtain and transfer new/existing knowledge simultaneously. These three levels of obtaining and transferring knowledge are connected by four social and psychological processes: intuiting, interpreting, integrating, and institutionalizing (4I). The 4Is occur within individual level, group level and organization level respectively. From intuiting and interpreting to integrating and institutionalizing, the process forms the first two stages of knowledge management: obtaining and organizing.

Researchers use various terms for knowledge obtaining such as Nonaka's knowledge creation (1991), Huber's knowledge acquisition (1991), Cohen and Levinthal's absorptive capacity (1990), and March's knowledge exploration and exploitation (1991). Other researchers extend the need for organizations to organize the newly acquired knowledge by interpretation, storing, integration, and distribution (Crossan *et al.*, 1999; Duffy, 2000; Huber, 1991; Zack, 1999). However, this study argues that if knowledge cannot facilitate organizations to create value, then "knowledge" is simply "information" or "data" at most. Information is mainly "descriptive" and it is contained in answers from *who, what, where, which, how many, when* questions. Knowledge, in contrast, is "instructive"; it is conveyed by answers to *how-to* questions (Gharajedaghi and Ackoff, 1984). Knowledge applying is an essential stage to transform the *how-to* vernaculars into sustainable value within the entire knowledge management process (Pfeffer and Sutton, 2000; Zack, 2000). Despite obtaining and organizing, organizations must be able to apply knowledge to sustain competitive advantage in today's intense competition.

CONCEPTUAL FRAMEWORK

While previous studies have suggested that knowledge management is important to organizational adaptiveness (e.g., Levinthal, 1991; March, 1991), most works are descriptive in nature and address little about how specific practices of knowledge management process contribute to organizational adaptiveness. The purpose of this study is to integrate prior learning and knowledge management aspects into a systematic process and propose an explicit relationship between knowledge management and organizational adaptiveness.

Knowledge obtaining

Before knowledge can be effectively manipulated to meet the goal of an organization, knowledge must be obtained. Knowledge is either created inside an organization or acquired from external sources (Duffy, 2000). The process of acquiring knowledge from external sources is knowledge acquisition. Organizations frequently attempt to identify outstanding practices from well-positioned competitors as well as partners, and then evaluate the current state of a particular process to identify gaps or problems in design. Once these variances are identified, organizations can capture the knowledge for internal use to improve performances (Porter and Millar, 1985; Thompson, 1967). Three most noticeable examples of methodologies utilized to accomplish this goal are benchmarking, strategic alliance and network. Despite knowledge acquisition, the process of creating knowledge inside an organization is knowledge creation. A knowledge creation process focuses on the tacit nature of knowledge, which resides inside the minds of different individuals or groups in an organization. Usually, organizations need to initiate a transformational process of tacit knowledge to explicit knowledge to enhance the applicability of more codified knowledge. Collaboration between employees, multi-unit project teams and R&D department are the most possible units to create new knowledge inside an organization.

Organizations differ in their abilities to integrate and replicate knowledge gained from external sources. This ability is labeled as “absorptive ability” (Cohen and Levinthal, 1990). Cohen and Levinthal (1990) argued that absorptive ability facilitates organizations to accumulate and renew the existing knowledge and hence, contribute to innovation. Cohen and Levinthal (1990) suggested that the ability to acquire and utilize the external knowledge is often associated with R&D investment, producing of innovations, and performance. Organizations are required to enhance their competency as well as the capability of innovation in order to survive in the turbulent environment.

New knowledge can be created or acquired either when existing knowledge are too obsolete to solve problems or when the necessity of new knowledge emerges. Intuitively, people generate knowledge by comparing new ideas, facts, or tools to ones they already know (McDermott, 1999). Nonaka and Takeuchi (1995) and Nonaka (1998) contend that knowledge can be created through the interaction of explicit knowledge and tacit knowledge within four different knowledge creation modes. Transforming tacit knowledge to tacit knowledge, where individuals acquire new knowledge directly from others, is defined as socialization. It is the process of experience sharing and implicit learning. In turn, tacit knowledge can transfer from one group to another. The process of making tacit knowledge explicit is externalization. It is the articulation of knowledge and transforms the knowledge into tangible form through dialogues. People can turn personal experiences, value concepts, and mental models into an explicit form with metaphor, analogy, and modeling. Internalization is the process of understanding and absorbing explicit knowledge into tacit knowledge held by individuals. It is the process of improving the values, attitudes, and behaviors by continually education, learning, and reading. Explicit knowledge can be transferred through a process called combination. It is the process of turning explicit knowledge into another explicit form. Analyzing, categorizing, sharing, and reconstruction of the existing explicit knowledge will produce new explicit knowledge (Nonaka and Takeuchi, 1995).

Summarizing existing literature, this study finds that researchers argue organization adaptation could be achieved successfully by obtaining knowledge from either internal or external sources (Duffy, 2000). Continuously obtaining knowledge (i.e., learning) to explore new possibilities and exploit certainties is essential for an organization’s survival (Crossan *et al.*, 1999; Levinthal, 1991; March, 1991). The question of whether an organization has the ability to learn from its environment and to respond to environmental changes quickly is central to this concept. Therefore, a hypothesis is generated as the following:

H1: Knowledge obtaining is positively related to organizational adaptiveness.

Knowledge Organizing

Knowledge organizing is the second stage after knowledge obtaining. This stage acts as an initial filtering mechanism for examining and identifying the potential pay off of organizations' purposeful use. This mechanism must logically exist in organizations to prevent the unnecessary absorbing of valueless knowledge. Knowledge organizing encompasses three sub-stages: refinement, storing, and distribution. Each stage is discussed in the following section.

Knowledge refinement

Knowledge refinery theory defines knowledge refinement as a value adding process before storing and distributing the newly captured knowledge to the repository or knowledge base (Zack, 1999). After obtaining the knowledge, organizations need to systematically add values by labeling, cleansing, standardizing, and abstracting to the knowledge platform for reviewers to examine and search easily. Knowledge refinement is perceived as the initial stage of internalizing the newly obtained knowledge and this mechanism can be used to enhance the effectiveness and efficiency of organizations' knowledge management. March (1991) argued that knowledge refinement is beneficial to both organizational exploration and exploitation, and in turn, contributes significantly to organizations' adaptive systems. The more effective and efficient knowledge refining activities that organizations have, the better organizations adapt to its environment. It leads to the following hypothesis:

H2a: Knowledge refinement is positively related to organizational adaptiveness.

Knowledge storing

Once the obtained knowledge has passed through the value adding process (i.e., refinement) and examined for its potential usefulness, organizations benefit from developing mechanisms for storing this knowledge. Knowledge storing, such as database and data warehousing, acts as a bridge between knowledge obtaining and distributing (Crossan *et al.*, 1999; Duffy, 2000; Huber, 1991; Zack, 1999). The structure of knowledge storage must accommodate multiple content views so that users can examine stored knowledge according to their own contextual needs. The content of knowledge storage will extend and grow over time if it is managed properly. Knowledge storing process forms an accessible platform and internal source for users to search for knowledge that best fits their needs and consequently facilitate organizations to better adapt to the environmental changes. Hence, the hypothesis is:

H2b: Knowledge storing is positively related to organizational adaptiveness.

Knowledge distribution

Knowledge distribution refers to the methods of delivering knowledge to users, groups, and organizations (Crossan *et al.*, 1999; Huber, 1991; Pfeffer and Sutton, 2000; Zack, 1999). Zack (1999) defined knowledge distribution as a mechanism that organizations adopt to make knowledge storage accessible. Knowledge distribution is usually mediated by organizational culture and frequency of communication (Buckman, 1998; Pfeffer and Sutton, 2000). Various organizational members and units that serve as knowledge acquirers also communicate and share knowledge to other organizational components (Huber, 1991). Knowledge needs to be readily available for users within organizations in searching for information that helps generate solutions. Effective and efficient retrieval and sharing depend on appropriate storage mechanisms, communications, multiple search techniques, well-developed indexing, classification schemes, and transparent accesses to disparate data sources (Duffy, 2000; Huber, 1991; Zack, 1999). Organizational ability to make quick and effective decisions is increased with efficient distribution of knowledge because individuals throughout the firm gain access to important strategic ideas, rather than merely retaining this knowledge within the ranks of high-level management. After exchanging information synergistically, shared knowledge provides a sense of complexity and risk associated with environmental contingencies and offers a rationale to organizations about how to adapt to environmental changes. Therefore, the hypothesis is:

H2c: Knowledge distribution is positively related to organizational adaptiveness.

Knowledge Applying

Knowledge applying is associated with the actual use of the knowledge. Pfeffer and Sutton (2000) argued that the competitive advantage goes to organizations that use knowledge the best, not to those who have the best knowledge.

They contended that unless the final stage of knowledge management, knowledge applying, is achieved in business world, the preceding stages of knowledge management are ineffective and will form a “knowing-doing gap” (Pfeffer and Sutton, 2000). Surprisingly, few discussions have been devoted to the results of effective applications of knowledge (Gold, Malhotra and Segars, 2001). For example, various scholars have researched on the subject of knowledge acquisition and creation and explicitly assume that once knowledge is obtained, it will be applied effectively (Nonaka, 1998; Nonaka and Takeuchi, 1995).

Wong and Radcliffe (2000) proposed a theoretical model of knowledge application. It emphasizes the relationship among different types of functional knowledge (i.e., from different departments, personnel), focal knowledge (i.e., knowledge needed to perform certain task), and the performance of the tasks. If the functional knowledge is able to support the focal knowledge involved in performing a task, organizations are likely to have better performance. As organizations increase learning and accumulate sufficient knowledge, organizations will perform better and possibly initiate strategic reorientation, and in turn, adapt to environmental changes more effectively and efficiently (Tushman and Romanelli, 1985). Thus, the following hypothesis is generated as the following:

H3: Knowledge application is positively related to organizational adaptiveness.

Knowledge management is a continuous process containing all three stages discussed in the present study. Each stage is essential for organizational adaptiveness and is likely the antecedent to the following stage. However, the newly obtained knowledge is useless if it cannot be transformed into organizational specific knowledge and refined knowledge without actual using is a waste of organizational resources. This study argues that organizations can maximize the synergy and adapt to the environment successfully only when all three knowledge management stages are implemented systematically and constantly. Therefore, it leads to the following hypothesis:

H4: The systematic process of knowledge obtaining, organizing, and applying is positively related to organizational adaptiveness.

Summarizing the above hypotheses, a theoretical framework is constructed. Organizational adaptiveness is the dependent variables and knowledge obtaining, knowledge organizing, and knowledge applying serve as the independent variables. Figure 1 shows the theoretical framework of this study.

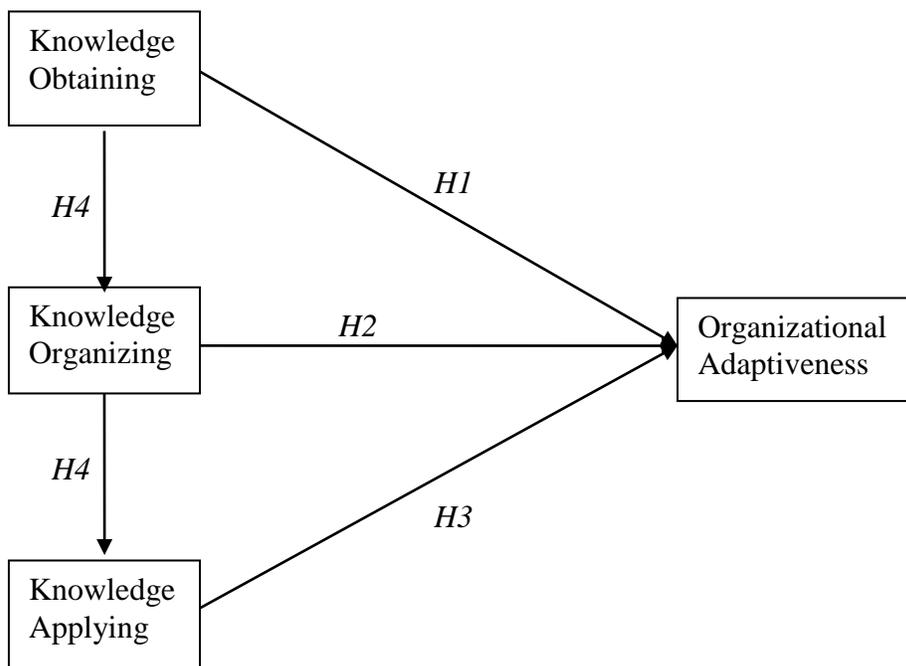


Figure 1 Theoretical Framework

METHODS

A number of conceptual based literatures are extended in knowledge management field. However, empirical studies are rare. This study uses survey research method to examine the relationship between knowledge management and organizational adaptiveness. A questionnaire based on previous literatures was developed due to the lack of existing measures in knowledge management. The scale items were refined based on expert reviews from several faculty members at major research universities. An exploratory factor analysis was conducted using SPSS before hypotheses testing because of the newness of this survey questionnaire. Further, the present study uses parallel analysis to decide the appropriate number of factorial components (Thompson and Daniel, 1996; Zwick and Velicer, 1986). The results suggested two factors for knowledge obtaining, three factors for knowledge organizing, two factors for knowledge applying, and two factors for organizational adaptiveness. Items measuring each construct were considered during the first run using principal components and varimax rotation at eigenvalue greater than one level. It resulted in items that did not load on the intended factors. Hence, minor modifications of the instrument were made to generate cleaner result of factor analysis after the first run and several items were extracted from the analysis. The resulting items were subjected to another factor analysis resulting in a model with a better fit. The results of factor analyses considered in the final instrument for each construct are shown in Table 1 to 4.

Table 1 Factor Analyses of Knowledge Obtaining

<i>Variable</i>	<i>Factor 1</i>	<i>Factor 2</i>	<i>Factor 3</i>
Knowledge Obtaining	Acquisition	Creation	
A1 frequently acquires knowledge from outside	.81		
A4 my org get valuable knowledge by monitoring competitor	.67		
A2 frequently cooperates with partners/Alliances	.64		
A5 my org acquire needed knowledge from contractual relationship	.62		
A3 frequently receives feedback from customers	.53		
A10 capable of analyzing, categorizing, systematizing general knowledge and transform into specific knowledge		.75	
A9 able to access database to acquire needed knowledge		.72	
A6 generated needed knowledge inside		.70	
A8 have formal procedures to develop knowledge		.64	
A7 have informal procedures to develop knowledge		.48	
Percentage of variance explained	.25	.25	
Cronbach's Alpha	.73	.74	

Table 2 Factor Analysis of Knowledge Organizing

<i>Variable</i>	<i>Factor 1</i>	<i>Factor 2</i>	<i>Factor 3</i>
Knowledge Organizing	Refinement	Distribution	Storing
B3 org has formal way of indexing knowledge	.88		
B2 org have formal way of categorizing knowledge	.87		
B4 org has formal way of integrating knowledge	.86		
B1 org has formal way of identifying knowledge	.82		
B5 org learning process makes knowledge integration efficient	.69		
B6 org learning process makes knowledge integration flexible	.64		
B15 expectation to share knowledge in my org		.80	
B14 willingness to share knowledge in my org		.77	
B16 willingness to share knowledge with partnering firms		.68	
B12 easily get knowledge from different department		.63	
B7 org has database to store knowledge			.81
B11 I can access the database to acquire needed knowledge			.79
<i>Percentage of variance explained</i>	.34	.20	.15
<i>Cronbach's Alpha</i>	.92	.76	.69

Table 3 Factor Analysis of Knowledge Applying

<i>Variable</i>	<i>Factor 1</i>	<i>Factor 2</i>	<i>Factor 3</i>
	Effectiveness	Value creation	
Knowledge Applying			
C9 org meets service objectives	.83		
C10 org meets quality objectives	.82		
C8 org meets satisfaction objectives	.82		
C11 org meets reliability objectives	.75		
C7 org meets budget objectives	.71		
C12 org meets major deadlines	.64		
C4 the collaboration among departments enhances the knowledge application		.79	
C6 knowledge enhances my org R&D		.78	
C5 knowledge helps problem solving		.76	
C2 org has ability to use knowledge flexibly to create value	.44	.68	
C3 my org culture enhances the application of knowledge		.67	
C1 org has ability to use knowledge effectively to create value	.51	.64	
<i>Percentage of variance explained</i>	.34	.30	
<i>Cronbach's Alpha</i>	.90	.87	

Table 4 Factor Analysis of Organizational Adaptiveness

<i>Variable</i>	<i>Factor 1</i>	<i>Factor 2</i>	<i>Factor 3</i>
	Capability	Innovation initiative	
Organizational Adaptiveness			
D5 org is capable of patenting new techniques/products/services	.78		
D20 org is able to speed up the new product/service design	.72		
D9 org have critical technology to gain competitive advantage	.70		
D11 org is involved in new product/service development	.70		
D10 org is capable of supporting R&D	.70		
D21 new product/service design is faster than competitors	.65		
D6 org is capable of importing new technology	.62		
D18 org frequently import new techniques to improve operation process	.62		
D19 org frequently develops new method to improve operation process	.59	.46	
D14 org is frequently looking for ways to shorten time to market	.58		
D4 capability assist my org to enter new MKT	.58	.43	
D16 org is frequently looking for ways to increase competitiveness		.80	
D1 org have capability to compete		.77	
D3 capability support my org to be competitive		.75	
D17 org is frequently looking for ways to enhance brand image		.70	
D2 org have equipment to allow for daily operations		.68	
D15 org is frequently looking for ways to increase profit margin		.68	
D13 org is frequently looking for ways to increase functionality	.42	.62	
D12 org is frequently looking for ways to improve quality	.44	.62	
<i>Percentage of variance explained</i>	.29	.26	
<i>Cronbach's Alpha</i>	.91	.89	

Convergent and discriminant validity were assessed by using factor analysis. Convergent validity is demonstrated if the items load strongly ($> .50$) on their associated factors (Grandon and Pearson, 2003). Discriminant validity was achieved when each item loads stronger on its associated factor than on any other factor (Grandon and Pearson, 2003; Hair, Anderson, Tatham and Black, 1998). Table 1 to 4 illustrate that all items loaded stronger on their associated factors than on other factors. Thus, convergent and discriminant validity were achieved. Internal consistency was assessed by using Cronbach's alpha (1951). Table 1 to 4 illustrate the alpha values ranged from .69 to .92, which indicates construct reliability is sufficient for all factors.

The research sample consists of students, who are either full or part time employees, at a major university in the southwest, faculty members of a college of business administration at a major research university in the southwest, and practitioners in a high technology company in Silicon Valley. Students, faculty members, and practitioners sample represent three types of organizations and are labeled as cross sectional employees, university, and tech firm in the analysis. The student sample represents general organizations while faculty member and practitioner sample represent knowledge intensive organizations but differing in industry nature. The reason this study considers the college of business administration of a university and a company in Silicon Valley knowledge intensive organizations is because the college of business administration contributes more to create knowledge while the high technology firm focuses more on applying knowledge to generate profits. The two organizations (i.e., college of business administration and high tech company) position in the industries with different natures and provide insights from different aspects, which contribute to the richness of this study. 57% of the student sample were full time employees, and 43% of the student sample were part time workers.

Respondents were asked to rate their perception on a five-point Likert Scale. Additional questions were asked regarding participant's demographic information. The target was to collect data from 200 participants from student sample, 100 participants from the faculty, and 100 from the technology company. After examining the complete surveys, 264 respondents' data are useable. 170 responses are from student sample, 40 from the faculty member sample, and 54 from the practitioner sample. 84% of the total respondents are aged between 20 and 40; 52% of the entire sample set are female, and the median level of education in the sample is college degree.

Measures/Variables

Knowledge obtaining

This construct represents the source of knowledge from which organizations obtain. Organizations can either acquire knowledge externally or create internally. Ten questionnaire items represent this construct. Respondents were asked to mark the source of knowledge using Likert scale ranging from 1, indicating highly disagree, to 5, indicating highly agree. The results of factor analysis suggested two factors for knowledge obtaining at .05 level. The final measures, labeled as *knowledge acquisition* and *creation*, explained 50% of variance and consisted of ten items. The Cronbach's alpha was .73 for acquisition and .74 for creation.

Knowledge organizing

This construct assists the understanding of what mechanism were applied in an organization and how well an organization implements knowledge management. Sixteen items are related to this construct. This study extracted four items, which cross-loaded in two or more factors. The result of factor analysis suggested three measures labeled as *refinement*, *storing*, and *distribution* at .05 level. Refinement contained six items; storing consisted of two items; distribution consisted of four items. Refinement, storing, and distribution explained 34%, 20%, and 15% of variances, respectively. The Cronbach's alpha of refinement, distribution, and storing is .92, .76, and .69, respectively.

Knowledge applying

This construct captures whether the organization improved its performance in product, market, service, and technology after employing knowledge management. A total of twelve items originally were related to this construct. The result of factor analysis suggested two factors for knowledge applying at .05 level. They were labeled as *effectiveness* and *value creation*. Effectiveness consisted of six items and value creation contained another six. Effectiveness explained 31% of variance and value creation explained 29% of variance. The Cronbach's alpha of effectiveness and value creation is .90 and .87, respectively.

Organizational adaptiveness

The dependent variable in this study is organizational adaptiveness and consists of two dimensions: *capability enhancement* and *innovation initiative* suggested from the result of factor analysis. A total of eleven items were related to capability and eight items were related to innovation initiative. The variances explained by capability and innovation initiative are 29% and 26%, respectively. Cronbach’s alpha of the two measures is .91 and .89, respectively.

RESULTS

Table 5 presents means, standard deviations, and correlations of the 7 independent and 2 dependent variables in this study. The values in the diagonal section of the correlation matrix indicate the alphas. As shown, all knowledge management stages are correlated with each other in a predicted pattern. The multi-collinearity diagnostics suggested multi-collinearity is not an issue in this study.

Table 5 Means, Standard Deviations, and Correlations

Variable	Mean	s.d.	1	2	3	4	5	6	7	8	9
1. Acquisition	3.71	.68	.73								
2. Creation	3.68	.70	.55**	.74							
3. Refinement	3.44	.79	.47**	.63**	.92						
4. Distribution	3.51	.75	.46**	.50**	.51**	.76					
5. Storing	3.64	.93	.32**	.48**	.45**	.42**	.69				
6. Effectiveness	3.65	.71	.42**	.51**	.54**	.51**	.38**	.90			
7. Value creation	3.66	.73	.54**	.61**	.68**	.66**	.46**	.67**	.87		
8. Capability Enhancement	3.54	.70	.51**	.56**	.63**	.48**	.41**	.51**	.66**	.91	
9. Innovation Initiative	3.89	.65	.60	.55	.58	.52	.38	.57	.65	.70	.89

N=264

**p<.01

To test the hypotheses 1 through 4 in the present study, two linear step-wise hierarchical regression analysis was conducted. To see whether the types of organizations would influence the relationships between knowledge management and organizational adaptiveness, we dummy coded the faculty and tech firm samples. In the two separate hierarchical regression analyses (one for each dependent variable), dummy coded variables of faculty and tech firm were introduced as control variables in model 1, knowledge acquisition and creation were extended in model 2, knowledge refinement, storing, and distribution were introduced in model 3, and effectiveness and value creation were inserted in model 4.

Table 6 illustrates the first regression analyses on capability enhancement and Table 7 represents the second regression analysis on innovation initiative. Results of model 1 in first regression analysis (Table 6) show that faculty, tech firm, and cross sectional employee are significant different when controlling the dummy coded variables. However, model 4 indicates that only tech firm is significantly different from other two sample groups. On the other hand, in the second regression analysis (Table 7), only faculty is significantly different from other two sample groups in model 1 but model 4 shows no significant differences among the three sample groups. Results of model 2 in both regression analyses indicate that, as anticipated, the data support a significant relationship between knowledge obtaining (i.e., acquisition and creation) and organizational adaptiveness (i.e., capability and innovation initiative). This finding supports Hypothesis 1 in this study.

Results of model 3 in both regression analyses show significant R-square increment of .11 and .07 in table 6 and 7 at p<.01 level. Hence, the results suggest that after controlling dummy variables and knowledge obtaining, knowledge organizing variables significantly explained 11% and 7% variances in capability enhancement and innovation initiative.

However, among the three knowledge organizing variables (i.e., refinement, storing, and distribution), only refinement and distribution produced significant beta values at .05 level which indicates significant positive relationships between refinement and distribution and organizational adaptiveness. Thus, Hypothesis 2a and 2c are supported while Hypothesis 2b is not supported.

In terms of knowledge applying, results of both hierarchical regression analyses (Table 6 and 7) show significant R-square change of .04 and .05 ($p < .01$). The results suggest that after controlling dummy variables, knowledge obtaining, and knowledge organizing, knowledge applying variables significantly explained 4% and 5% variances of organizational adaptiveness. This finding supports Hypothesis 3 in the present study. Surprisingly, effectiveness in the first regression (Table 6) is not significantly related to capability enhancement.

From model 4 in both regression analyses, the values of R-squares are .54 and .55, respectively at .01 level, which suggest that the sequential, step-wise knowledge management process is significantly related to organizational adaptiveness. Therefore, Hypothesis 4 is supported. However, in the first regression analysis (Table 6), only knowledge acquisition, refinement, and value creation are significantly ($p < .05$) related to capability enhancement. On the other hand, in the second regression analysis, knowledge acquisition, refinement, effectiveness, and value creation are significantly ($p < .05$) related to innovation initiative.

As predicted, each stage of knowledge management, namely knowledge obtaining, organizing, and applying, is positively and significantly associated with organizational adaptiveness which is consistent with the argument developed in this study. The results of regression analyses also indicate that all Hypotheses except Hypothesis 2b are significantly supported. The p values show that some specific knowledge management processes are more important to organizational adaptiveness (i.e., capability enhancement and innovation initiative).

Table 6 Regression with Dummy Variables in Capability Enhancement

Independent Variable	Dependent Variable: <i>Capability Enhancement</i>			
	Model 1	Model 2	Model 3	Model 4
Intercept	3.53	1.05	.69	.52
Dummy of Faculty	(.27)**	(.20)**	(.23)	.03
Dummy of Tech Firm	.27**	.17*	.24***	.25***
Acquisition		.26***	.17***	.12**
Creation		.41***	.14**	.09
Refinement			.34***	.24***
Distribution			.09**	(.02)
Storing			.05	.04
Effectiveness				.07
Value creation				.29***
F	6.62***	40.34***	35.60***	32.65***
R2	.05	.39	.50	.54
$\Delta R2$	-	.34***	.11***	.04***

*** $p < .01$
 ** $p < .05$
 * $p < .1$

Table 7 Regression with Dummy Variables in Innovation Initiative

Dependent Variable: <i>Innovation Initiative</i>				
Independent Variable	Model 1	Model 2	Model 3	Model 4
Intercept	3.92	1.36	1.03	.81
Dummy of Faculty	(3.00)***	(.21)**	(.08)	(.01)
Dummy of Tech Firm	.07	(.03)	.02	.04
Acquisition		.39***	.32***	.27***
Creation		.31***	.11*	.05
Refinement			.18***	.09**
Distribution			.13***	.03
Storing			.07	.06
Effectiveness				.15***
Value creation				.21***
F	4.16**	49.50***	36.84***	34.18***
R2	.03	.44	.51	.55
ΔR2	-	.41***	.08***	.05***

****p* < .01
 ***p* < .05
 **p* < .1

This study used three different types of sample groups and created dummy variables to represent each sample group. The authors are also interested in what knowledge management variables are different across three sample groups. Table 8 and illustrates the ANOVA and Table 9 shows the multiple comparisons of the three sample groups. Results of ANOVA show that all variables except creation are different across sample group at .1 level. From the multiple comparisons, this study finds a pattern which is cross section employee and tech firm are not significantly different but faculty and tech firm and cross sectional employee are significantly different at least .05 level.

Table 8 Analysis of Variance

	Student	Faculty	Tech Firm	F value
Acquisition	3.71	3.46	3.90	4.87**
Creation	3.66	3.57	3.82	1.64
Refinement	3.52	3.06	3.47	5.77**
Distribution	3.55	3.23	3.63	3.64*
Storing	3.69	3.26	3.79	4.31*
Effectiveness	3.74	3.25	3.63	7.46**
Value creation	3.72	3.29	3.75	6.02**
Acquisition	3.53	3.24	3.81	7.85**
Creation	3.92	3.59	4.01	5.24**

***p* < .01
 **p* < .05

Table 9 Multiple Comparisons of Variables

Dependent Variable	Sample Group Comparison		Sig.
Acquisition	student	tech firm	.239
		university	.099
	tech firm	university	.006
		student	.405
Creation	student	tech firm	.405
		university	1.000
	tech firm	university	.277
		student	1.000
Refinement	student	tech firm	1.000
		university	.002
	tech firm	university	.038
		student	1.000
Distribution	student	tech firm	1.000
		university	.050
	tech firm	university	.036
		student	1.000
Storing	student	tech firm	1.000
		university	.028
	tech firm	university	.019
		student	.966
Effectiveness	student	tech firm	.966
		university	.000
	tech firm	university	.038
		student	1.000
Value creation	student	tech firm	1.000
		university	.003
	tech firm	university	.009
		student	.028
Capability	student	tech firm	.028
		university	.058
	tech firm	university	.000
		student	1.000
Innovation	student	tech firm	1.000
		university	.014
	tech firm	university	.007

DISCUSSION

Organizational adaptation is highly related to both contingency theory and environmental selection process. Knowledge management has been suggested as a critical factor for increasing the chance of successful organizational adaptation (Levinthal, 1991; March, 1991; Scott, 1987). Moreover, knowledge management is considered an effective way for remaining competitive in turbulent environment and for improving the overall innovativeness of an organization (Amabile, 1998; Kanter, 1988; Shalley, 1991; Shalley *et al.*, 2000). This study focuses on how knowledge management enhances organizational adaptiveness by discriminating and analyzing the stages of knowledge management. The results of this study provide empirical support for theories of knowledge management and establish a connection between knowledge management and organizational adaptiveness. Moreover, the results of analyses suggest that knowledge management is significantly associated with organizational adaptiveness. Knowledge acquisition, refinement, and value creation are more important especially when an organization's adaptation system emphasizes on enhancing organizational capability. However, knowledge acquisition, refinement, effectiveness, and value creation are more important if an organization's adaptation system focuses on innovation. The differences of the results of capability enhancement and innovative initiative are apparent. The enhancement of organizational capability and competency depends on the knowledge transparency inside the organization (Hamel, 1991). Organizational knowledge needs to be refined, codified, and integrated into the knowledge management system to be transformed into organizational capability and competency easily. Differential capabilities for acquiring new component knowledge are the key for an organization to innovate (Cohen and Levinthal, 1990; Tallman *et al.*, 2004). An organization needs to "decipher" knowledge after acquiring new knowledge, and apply it to create the next round innovations.

The results indicate that knowledge applying is significantly associated with both capability and innovation initiative, which support the argument in the present study that knowledge needs to be applied to create value. Knowledge storing and distribution are not significant here as shown in the analysis (Table 6 and 7). However, many other research findings suggest that knowledge distribution and storing will naturally occur when knowledge is refined, less tacit, and sufficiently transparent (Hamel, 1991; Zahra and George, 2002).

ANOVA was used to examine the mean differences to support the argument and conclusion shown above. The ANOVA from table 8 shows the means of faculty members is the lowest of the three sample groups. Students and technology firm practitioners tend to have closer mean values. A possible explanation for this finding might be the different nature of academia and industry. Faculty members are like independent contractors and might tend to adopt knowledge management process for their own purpose and contribute less to overall organizational adaptiveness (i.e., college of business administration). As for students and practitioners, from table 6 and 7, the results of regression analyses reveal that the adoption of knowledge management indeed contribute significantly to organizational innovation initiative and capability enhancement.

These research findings provide implications for both researchers and practitioners in this area because few prior studies had empirical support and tied knowledge management process to organizational adaptiveness.

LIMITATIONS AND IMPLICATIONS FOR RESEARCH AND MANAGEMENT

The major contribution of this work is a coherent model that integrates two highly related fields, namely knowledge management and organization learning, into a systematic order to propose a link between knowledge management and organizational adaptiveness. An underlying assumption about the role of organizational learning toward organizational adaptiveness has been examined. This study emphasizes how organizations create value through actual knowledge application and how knowledge management processes promote organizational adaptiveness effectively. Moreover, the findings of this study suggest that knowledge applying is an influential factor in knowledge management process.

One major implication of this study for both researchers and practitioners is to reinforce the value of effective knowledge management process for an organization when facing a turbulent environment. Previous literature has observed a tendency to equate learning to organization's competitive advantage. This perspective lacks the significant role of knowledge application. This study argues that organizations eventually need to apply knowledge to create value in order to sustain competitive advantage and enhance organizational adaptiveness either by exploratory or exploitative learning from internal or external sources. Practitioners need to address the complete knowledge management process, rather than merely organizational learning in today's intense competition. Moreover, the different natures of industry also influence the knowledge management adoption. The analytical results find that university faculty members tend to focus on early knowledge management stages and practitioners emphasize on mid-end stages of knowledge management process. This results also suggest that faculty members tend to be knowledge gatekeepers while practitioners are more like knowledge users.

This study has limitations. One limitation is the limited population of the samples. The sample size of 264 respondents might not be sufficient for a thorough analysis of higher power. This would affect the generalizability of the findings. The other limitation is the nature of the sample. This present study chose the students who currently have jobs to be part of the research subjects in this study. The potential problem of a convenient sample is the lack of representability. Furthermore, a number of contingent factors, such as leadership, politics, culture, inter-organizational relationship, and trust, may need more attentions. These contingent variables could moderate or mediate the theoretical model of this study. Future empirical research will need to address the issues of various contingent variables in different organizations to gain the generalizability of this study.

REFERENCES

- Amabile, T.M. (1988). "A model of creativity and innovation in organizations", In B.M. Staw and L.L. Cummings (Eds.), *Research in Organizational Behavior*, 10, pp.123-167. Greenwich, CT: JAI press.
- Astley, W.G. and Van de Ven, A. (1983). "Central perspectives and debates in organizational theory", *Administrative Science Quarterly*, 28, pp.245-273.
- Bock, W. (2000). "Knowledge management 101", *Intranet Journal*, Online available: http://www.intranetjournal.com/articles/200011/ic_11_29_00a.html
- Brown, S. and Eisenhardt, K. (1998). *Competing on the Edge*, Boston, MA: Harvard Business School Press.
- Buckman, R.H. (1998). "Knowledge sharing at Buckman Labs", *Journal of Business Strategy*, 19 (1), pp.1-15.
- Burns, T. and Stalker, G.M. (1995). *The Management of Innovation*, New York, NY: Oxford University Press.
- Cohen, W.M. and Levinthal, D.A. (1990). "Absorptive Capacity: A new perspective on learning and innovation", *Administrative Science Quarterly*, 35, pp.128-152.
- Corno, F., Reinmoeller, P. and Nonaka, I. (1999). "Knowledge creation within industrial systems", *Journal of Management and Governance*, 3(4), pp.379-394.
- Cronbach, L.J. (1951). "Coefficient alpha and the internal structure of tests", *Psychometrika*, 16, pp.297-334.
- Crossan, M., Lane, H. and White, R. (1999). "An organizational learning framework: from intuition to institution", *Academy of Management Review*, 24, pp.522-538.
- Cyert, R.M. and March J.G. (1963). *A Behavioral Theory of the Firm*, Englewood Cliffs, NJ: Prentice-Hall.
- DeGeus, A. (1988). "Planning as learning", *Harvard Business Review*, 66(2), pp.70-74.
- DeTienne, K.B. and Jackson, L.A. (2001). "Knowledge management: Understanding theory and developing strategy", *Competitiveness Review*, 11(1), pp.1-11.
- Drucker, P.E. (1994). *Post-Capitalist Society*, New York, NY: Harperinformation Press.
- Duffy, J. (2000). "The KM technology infrastructure", *Information Management Journal*, 34(2), pp.62-66.
- Gharajedaghi, J. and Ackoff, R. (1984). "Mechanisms, organisms and social systems", *Strategic Management Journal*, 5, 289-300.
- Gold, A.H., Malhotra, A. and Segars, A.H. (2001). "Knowledge management: An organizational capabilities perspective", *Journal of Management Information Systems*, 18(1), pp.185-214.
- Grandon, E. and Pearson, J.M. (2003). "Strategic value and adoption of electronic commerce: an empirical study of Chilean small and medium businesses", *Journal of Global Information Technology Management*, 6(3), pp.22-43.
- Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C. (1998). *Multivariate Data Analysis*, New Jersey, NJ: Prentice Hall.
- Hamel, G. (1991). "Competition for competence and inter-partner learning within international strategic alliances", *Strategic Management Journal*, 12, pp.83-104.
- Hannan, M.T. and Freeman, J. (1977). "The population ecology of organizations", *American Journal of Sociology*, 82, pp.929-964.
- Hannan, M.T. and Freeman, J. (1984). "Structural inertia and organizational change", *American Journal of Sociology*, 82, pp.929-964.
- Hannan, M.T. and Freeman, J. (1989). *Organizational Ecology*, Cambridge, MA: Harvard University Press.
- Holland, J. (1975). *Adaptation in Natural and Artificial Systems*, Ann Arbor, MI: University of Michigan Press.
- Huber, G. (1991). "Organizational learning: the contributing processes and the literatures", *Organization Science*, 2, pp.88-115.
- Kanter, R.M. (1988). "When a thousand flowers boom: structural, collective, and social conditions for innovation in organizations. In B.M. Staw and L.L. Cummings (Eds.), *Research in Organizational Behavior*, 10, pp.162-211. Greenwich, CT: JAI press.
- Kogut, B and Zander, U. (1992). "Knowledge of the firm, combinative capacities and the replication of technology", *Organization Science*, 78, pp.383-397.

- Kuran, T. (1988). "The Tenacious Past: Theories of Personal and Collective Conservatism", *Journal of Economic Behavior and Organization*, 10, pp.143-171.
- Lawrence, P.R. and Lorsch, J.W. (1967). *Organization and Environment: Managing Differentiation and Integration*, Boston, MA: MIT Press.
- Leonard-Barton, D. (1992). "The factory as a learning laboratory", *Sloan Management Review*, 34(1), pp.23-38.
- Levinthal, D.A. (1991). "Organizational adaptation and environmental selection-Interrelated processes of change", *Organization Science*, 2(1) pp.140-145.
- Levitt, B. and March, J. (1988). "Organizational learning", *Annual Review of Sociology*, 14, pp.319-340.
- March, A.S. (1991). "Exploration and exploitation in organizational learning", *Organization Science*, 2(1), pp. 71-87.
- March, J.G. and Simon, H.A. (1958). *Organizations*, New York, NY: Wiley Press.
- Marshall, L. (1997). "Facilitating knowledge management and knowledge sharing: New opportunities for information professionals", *Online*, 21(5), pp.91-98.
- McDermott, R. (1999). "Why information technology inspired but cannot deliver knowledge management", *California Management Review*, 41(4), pp.103-117.
- McGrath, R.G. (2001). "Exploratory learning, innovative capacity, and managerial oversight", *Academy of Management Journal*, 44(1), pp.118-131.
- Nelson, R.R. and Winter, S.G. (1982). *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press.
- Nonaka, I. (1991). "The knowledge creating company", *Harvard Business Review*, 69(6), pp. 96-105.
- Nonaka, I. (1998). "The concept of ba: Building a foundation of knowledge creation", *California Management Review*, 40(3), pp.40-54.
- Nonaka, I. and Takeuchi, H. (1995). *The Knowledge Creating Company: How Japanese Create the Dynamics of Innovation*, New York, NY: Oxford University Press.
- Pfeffer, J. and Sutton, R.I. (2000). *The Knowing-Doing Gap: How Smart Companies Turn Knowledge into Action*, Cambridge, MA: Harvard Business School Press.
- Porter, M.E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*, New York, NY: Free Press.
- Raisinghani, M.S. (2000). "Knowledge management: a cognitive perspective on business and education", *American Business Review*, 18 (2), pp.105-112.
- Schumpeter, J. (1934). *The Theory of Economic Development*, Cambridge, MA: Harvard University Press.
- Schumpeter, J. (1950). *Capitalism, Socialism, and Democracy*, New York, NY: Harper and Row Press.
- Scott, W.R. (1987). *Organizations: Rational, Natural, and Open Systems*, Englewood Cliffs, NJ: Prentice-Hall.
- Senge, P.M. (1994). *The Fifth Discipline: The Art and Practice of the Learning organization*, New York, NY: Currency Doubleday.
- Shalley, C.E. (1991). "Effects of productivity goals, creativity goals, and personal discretion on individual creativity", *Journal of Applied Psychology*, 76, pp.179-185.
- Shalley, C.E., Gilson, L.L., and Blum, T.C. (2000). "Matching creativity requirements and the work environment: effects on satisfaction and intentions to leave", *Academy of Management Journal*, 43(2), pp.215-223.
- Simon, H. (1945). *Administrative Behavior*, New York, NY: Free Press.
- Simon, H. (1991). "Bounded rationality and organizational learning", *Organization Science*, 2, pp.125-134.
- Tallman, S., Jenkins, M., Henry, N., and Pinch, S. (2004). "Knowledge, clusters, and competitive advantage", *Academy Management Review*, 29(2), pp.258-271.
- Thompson, B. and Daniel, L.G. (1996). "Factor analytic evidence for the construct validity of scores: a historical overview and some guidelines", *Educational and Psychological Measurement*, 56(2), pp.197-208.
- Trepper, C. (2000). "Keep your knowledge in-house", *Information Week*, Sept, pp.802-806.
- Tsai, W. (2001). "Knowledge transfer in intra-organizational networks: effects of network position and absorptive capacity on business unit innovation and performance", *Academy of Management Journal*, 44(5), pp.996-1004.

- Tsai, W. and Ghoshal, S. (1998). "Social capital and value creation: The role of intra-firm networks", *Academy of Management Journal*, 17, pp.27-43.
- Tushman, M.L. and Romanelli, E. (1985). "Organizational evolution: A metamorphosis model of convergence and reorientation", in Cummings, L.L. and Staw, B.M. (Eds.), *Research in Organizational Behavior*, 7, pp.171-222.
- Vera, D. and Crossan, M. (2003). "Organizational learning and knowledge management: toward an integrative framework", In M. Easterby-Smith and M. Lyles (Eds.), *Handbook of Organizational Learning*, pp. 122-141, Oxford, MA: Blackwell Press.
- Vera, D. and Crossan, M. (2004). "Strategic leadership and organizational learning", *Academy of Management Review*, 29(2), pp.222-240.
- Weick, K.E. (1991). "The non-traditional quality of organizational learning", *Organization Science*, 2, pp.116-124.
- Wilson, L.T. and Asay, D. (1999). "Putting quality in knowledge management", *Quality Progress*, 32(1), pp.25-31.
- Wong, W.L.P. and Radcliffe, D.F. (2000). "The tacit nature of design knowledge", *Technology Analysis and Strategic Management*, 12(4), pp.493-512.
- Zack, M.H. (1999). "Managing codified knowledge", *Sloan Management Review*, 40(4), pp.45-48.
- Zahra, S.A. and George, G. (2002). "Absorptive capacity: a review, reconceptualization, and extension", *Academy of Management Review*, 27, pp.185-203.
- Zwick, W.R. and Velicer, W.F. (1986). "Comparison of five rules for determining the number of components to retain", *Psychological Bulletin*, 99(3), pp.432-442.