Knowledge Management Performance Index Considering Knowledge Cycle Process

Kun Chang Lee[1], SoonJae Kwon[2], Namho Chung[2], Soochoul Joung[2], Byung-uk Kang[2]

Abstract. This paper is aimed at proposing a new metric named KMPI (Knowledge Management Performance Index) to evaluate the performance of knowledge management (KM) at a point in time. Firms are assumed to have always been oriented toward accumulating and applying knowledge to create economic value and competitive advantage. On the basis of this assumption, we suggest KMPI, a new metric having a logistic function with five components of knowledge circulation process (KCP)- knowledge creation, knowledge accumulation, knowledge sharing, knowledge utilization, and knowledge internalization. If KCP efficiency increases, then KMPI will become greater, which means that firms are now becoming knowledge-intensive businesses. To prove the contribution of KMPI more formally, questionnaire survey was conducted extensively among 101 firms listed in KOSDAQ market in Korea, and we associated KMPI with three financial measures such as stock price, PER, and R&D expenditure. Statistical results show that the proposed KMPI can represent the KCP efficiency, and go along with the three financial performance measures.

Keywords: *Knowledge management performance; Knowledge circulation process; Logistic function; KMPI; Factor analysis*

1. INTRODUCTION

A knowledge-based view of the firm, which has emerged as one of important strategic management topics, provides theoretical basis about why knowledge-based resources are playing an important role in increasing sustainable competitiveness of the firm (Cole, 1998; Spender, 1996ab; Nonaka and Takeguchi, 1995). The resource-based view of the firm suggested by Penrose (1959), Barney (1991), Teece (1998), and Wernerfelt (1984) promotes the knowledge-based perspective of the firm, which postulates that competitive advantage builds upon those privately developed resources, tacit and explicit, developed inside the firm. Likewise, the knowledge-based view of the firm posits that the knowledge assets existing at any given time per se, one of those idiosyncratic resources proprietarily created and accumulated in the firm for years, produce sustainable competitive advantage. In this new era of highly competent IT, this knowledge-based view of the firm can explain convincingly why certain firms show more competitiveness under the same market situation. The knowledge assets are dependent upon the quality of organizational knowledge and intangible assets in general (Grant, 1996ab). Even though we adopt the knowledge-based view of the firm, there exists an important research question- why do most firms that initiated KM still struggle with the development of appropriate metrics to assess the effectiveness of their initiatives. In other words, they need some metrics to justify their KM initiatives financially. They don't want to make their KM look like pure research activity that may some day lead to remarkable increase in management productivity and performance. In any case, linking KM initiatives to important financial measures may help to justify KM investments to senior management and more importantly improve the firm's ability to manage knowledge assets effectively. Given that several KM benefits are intangible, one measurement method that is growing in popularity is the balanced scorecard (Kaplan and Norton, 1992). Alongside financial measures, the balanced scorecard includes other perspectives, i.e., customers, internal business processes, as well as innovation and learning. However, linking KM initiatives to performance measures both tangible and intangible is not enough. We need a more rigorous measurement metric to assess the KM performance with an ability to explain it and suggest future strategic movement the firms should take to improve their KM performance. To address this research question and need, our research objective is to propose a new measurement metric, named KMPI (Knowledge Management Performance Index), to evaluate KM performance. Basic assumption underlying KMPI is that knowledge may be viewed from an unified perspective – it has multi-faceted characteristics like a state of mind (Schubert et al., 1998), an object (Carlsson et al, 1996; McQueen, 1998), a process (Zack, 1998), a condition of having access to information (McQueen, 1998), a capability with the potential for influencing future action (Carlsson et al, 1996; Watson, 1999). Alavi and Leidner (2001) summarized well the distinction between each perspective about knowledge. Table 1 is an excerpt from p.121 in Alavi and Leidner (2001).

Table 1. Diverse perspectives of knowledge and their implications for KM (Excerpt from Alavi and Leidner (2001), p.111)

Perspectives		Implications for KM
State of mind	Knowledge is the state of knowing and understanding	KM involves enhancing individual's learning and understanding through provision of information
Object	Knowledge is an object to be stored and manipulated	Key KM issue is building and managing knowledge stocks
Process	Knowledge is a process of applying expertise	KM focus is on knowledge flows and the process of creation, sharing, and distributing knowledge
Access to information	Knowledge is a condition of access to information	KM focus is organized access to and retrieval of content
Capability	Knowledge is the potential to influence action	KM is about building core competencies and under standing strategic knowhow

[1] Professor of MIS, School of Business Administration, Sung Kyun Kwan University, Seoul 110-745, Korea, leekc@skku.ac.kr
[2] Graduate School of Business Administration, Sung Kyun Kwan University, Seoul 110-745, Korea

Table 2. Five categories of KM studies

Category	Implications	Sub-categories	Researches
General	Several managerial and social issues pertaining to KM are dealt with.	KM strategy and organizational culture	Pentland (1995), Alavi and Leidner (1999), Zack (1999)
		Specific processes and activities within KM	Petrash (1996), Szulanski (1996), Alavi (1997), Elliott (1997), Van der Spek and Spijkervet (1997), Choo (1998), Holsapple and Joshi (1999)
		Review and research agenda	Davenport and Glover (2001), Gold et al. (2001), Alavi and Leidner (2001)
Learning organization	Firms maintain organizational knowledge to obtain a sustainable competitive advantage.	Organizational knowledge	Stata (1989), Senge (1990), El Sawy et al. (1986), Schatz (1991-1992), Stein and Zwass (1995), Walsh and Ungson (1991), Tuomi (2000), Markus (2001)
		Learning capability and design of leaning organization	Purser et al., (1992), Roth and Senge (1996), Van de Ven and Pooley (1992), Shaw and Perkins (1992), McGill and Slocum (1994), Leonard-Barton (1995)
Knowledge assets evaluation	Valuing and measuring intangible assets promotes organizational learning and generates organizational capabilities.	Intellectual capital	Brooking (1996), Edvinsson (1997), Sveiby (1998)
		Balanced Score Card	Kaplan and Norton (1992)
		Strategic organizational learning and organizational capabilities	Massey et al. (2001), Roos and Roos (1998), Sakaiya (1991), Stewart (1997), Teece (1998, 2000), Leonard and Sensiper (1998)
Role of IT	KM should be supported by IT and/or KMS so that KM can contribute to increasing management performance.	Knowledge Management System (KMS)	Alavi (1997), Alavi and Leidner (1999, 2001), Baird et al. (1997), Bartlett (1996), Davenport et al. (1996), Gray (2000), Henderson and Sussman (1997), Rouse et al. (1998), Sensiper (1997), Watts et al. (1997)
		Role of IT in KM in general	Alavi and Leidner (1999), Newell and Scarbrough (1999), Pérez-Bustamante (1999)
		Role of IT for specific KM activities	Liou and Nunamaker (1993), Khalifa (1998), Fischer et al. (1999), Petraglia and Glass (1999), Squires (1999), Suthers (1999)
		Knowledge mining and DSS for KM	Rouse et al. (1998), Holsapple and Joshi (2001)
		Strategic use of the Internet	Dieng (2000), Martin and Eklund (2000), Dominique and Motta (2000), Schwartz and Te'eni (2000), Rabarijaona et al. (2000), Szykman et al. (2000), Caldwell et al. (2000)
Success and failure factors	Success factors for KM should be given sufficient consideration before launching KM strategy.		Davenport et al. (1996), Ruggles (1998), Glasser (1999), Krogh (1998)

Based on the unified perspective of knowledge, this paper posits the following four assumptions without loss of practicality and theoretical generality: (1) KM activities may be reduced into performing knowledge circulation process (KCP) in which there exist five components making KM operational in the firm- knowledge creation, knowledge accumulation, knowledge sharing, knowledge utilization, and knowledge internalization.
(2) KM is defined here tactically by all kinds of management activities promoting KCP in a firm.
(3) A firm can increase its flexibility and adaptability to rapidly changing business environment by focusing on the efficiency of KM activities.
(4) Within the firms adopting KM, KMPI will gradually increase with time.
The layout of the paper is as follows. In the following section, we describe the previous studies to justify our research objective. Section 3 explains fundamentals and theoretical backgrounds of the proposed KMPI. Research hypotheses are suggested. Then the empirical study is suggested with promising results, in Section 4. In conclusion, this paper is ended with discussing contributions of this research and future research directions.

2. PREVIOUS STUDIES

Previous studies on KM builds on multiple disciplines, e.g., management, computer science, and information systems. To maintain consistency in our literature survey on KM and to justify our research objective, i.e. to suggest a new measurement metric named KMPI for assessing the KM performance, we classify previous KM literature into five categories- (1) general, (2) learning organization, (3) knowledge assets evaluation, (4) role of IT, (5) success and failure factors, all of which are summarized in Table 2.

First category deals with managerial and social issues related to KM. Some studies (e.g., Pentland, 1995, Alavi and Leidner, 1999, Zack, 1999) stressed the importance of the strategy driving KM and the organizational culture within which KM takes place. Other studies focused directly on specific processes and activities within KM, e.g., knowledge acquisition, generation, storage, distribution, application and measurement (Petrash, 1996; Szulanski, 1996; Alavi, 1997; Elliott, 1997; Van der Spek and Spijkervet, 1997; Choo, 1998; Holsapple and Joshi, 1999). Also, research agenda and general perspective of KM based on extensive literature review are presented (Gold et al.,2001; Davenport and Grover, 2001; Alavi and Leidner, 2001).
Second category takes management perspective that deals with questions about what learning organization means for obtaining a sustainable competitive advantage. Especially, according to Stata (1989) and Senge (1990), learning is the only sustainable competitive advantage for organization, and learning ends up with leaving organizational knowledge (or memory) (El Sawy et al., 1986; Schatz, 1991-1992; Stein and Zwass, 1995; Walsh and Ungson, 1991). Markus (2001) shows a theory of organizational knowledge reuse. A sustainable competitive advantage may be obtained through organizational knowledge which is a corporate memory having an effect on present decisions and playing as an important factor in the success of an organization's operations and responsiveness to the changes and challenges of environment (Stein and Zwass, 1995; Walsh and Ungson, 1991). There have been increasing attempts to help organizations improve their learning capability and to design themselves as learning systems (Purser et al., 1992; Roth and Senge, 1995). In addressing how organizations can improve their learning capability, researchers have identified a number of problems that organizations face when trying to learn (Van de Ven and Pooley, 1992; Shaw and Perkins, 1992; McGill and Slocum, 1994; Leonard-Barton, 1995).
Third category is concerned with evaluation of knowledge assets. Practicing KM for years can produce various forms of intangible assets or intellectual capital within firms. Such intangible assets are intellectual capital. Edvinsson (1997) shows, based on case study of Skandia, that the intellectual capital of a firm can be measured, documented, and monitored. Brooking (1996) analyzes the multiple components of intellectual capital and provides lists of high-level questions useful for auditing an organization's intellectual capital. In addition, Sveiby (1998) details how to effectively use and measure intangible assets and how to monitor them for financial success. Kaplan and Norton (1992) develop Balanced Score Card (BSC) using a combination of measures in four categories, financial performance, customer knowledge, internal business processes, and learning and growth, to align individual, organizational and cross-departmental initiatives. They expect that the BSC will help companies test and update their strategy and meet their customer's needs and shareholder's objectives more effectively. Measuring the knowledge assets promotes strategic organizational learning (Brooking, 1996; Edvinsson, 1997; Massey et al., 2001; Roos and Roos, 1998; Sakaiya, 1991; Stewart, 1997; Teece, 1998, 2000), and generates the renewable organizational capabilities required to meet customer expectations on an ongoing basis (Leonard and Sensiper, 1998).
Fourth category of KM studies are addressing a role of IT in KM. The role of IT is investigated in KM in general (Alavi and Leidner, 1999; Newell and Scarbrough, 1999; Pérez-Bustamante, 1999) or for specific KM activities in particular (e.g., Liou and Nunamaker, 1993; Khalifa, 1998; Fischer et al. 1999; Petraglia and Glass, 1999; Squires, 1999; Suthers, 1999). KMS, Knowledge Management System, is a specialized information system for KM using modern technologies (e.g. the Internet, intranets, browsers, data warehouses, and software agents) in order to systematize, facilitate, and expedite firm-wide KM (Alavi and Leidner, 1999; Rouse et al., 1998). The KMS researches consist primarily of general and conceptual principles of KMS (Davenport et al., 1996) and case studies of such systems in a handful of leading organizations (Alavi, 1997; Baird et al., 1997; Bartlett, 1996; Henderson and Sussman, 1997; Sensiper, 1997; Watts et al., 1997). Especially, Gray (2000) describes how KMS can enhance the effectiveness of teams that analyze complex, non-recurring problems by improving the way that team composition evolves. Knowledge mining is similar to data mining. However, Rouse et al. (1998) uses knowledge mining to extract some knowledge from several data sources and apply it for more complicated and value-added problems. Holsapple and Joshi (2001) argue that DSS could be used to get the right knowledge in the right form to the right persons at the right time. Several papers are tackled technically from the perspective of a strategic use of the Internet for KM activities. Dieng (2000) discusses the potential of the Internet and intranets in developing distributed KMS. XML-based meta language is developed for knowledge retrieval from the knowledge repository administered on the web (Martin and Eklund, 2000). A KMS prototype named PlanetOnto, operating on the Internet, is suggested to support an academic community to collaboratively construct and share an archive of news items (Domingue and Motta, 2000). Schwartz and Te'eni (2000) exploit the Internet and e-mail to disseminate knowledge. Rabarijaona et al. (2000) addresses using XML to support users to translate a corporate ontology into an annotation document type definition. A representational infrastructure and a computational DSS framework are suggested for creating design repositories on the Internet (Szykman et al., 2000) and assisting a distributed team of designers in conceptual design evaluation on the web (Caldwell et al., 2000).
Fifth category is to explore success and failure factors of KM. Davenport et al. (1996), from successful KM projects, find out eight key factors to help a company create, share, and use knowledge efficiently. Ruggles (1998) identifies the KM concepts from over 400 firms in U.S and Europe and finds out what the barriers to KM are. Success factors for KM include compensation against knowledge provider, incentive systems, organization culture, etc. (Glasser, 1999; Krogh, 1998).
From the literature survey about KM, we can conclude that there is no study denoting a research objective similar to this paper, which is to propose a new measurement metric named KMPI for assessing KM performance. Then the next step should be what methodology is adopted to accomplish our research objective.

3. METHODOLOGY

3.1 Fundamentals of KMPI and Research Hypotheses

KCP includes a whole process of knowledge diffusion within a firm- knowledge creation, knowledge accumulation, knowledge sharing, knowledge utilization, knowledge internalization. KCP has a dynamic nature because it represents a knowledge flow concept where five components of knowledge circulation are

interlinked with each other. Since KCP denotes a knowledge flow concept, and it is dynamic with time, we introduce time *t* into the KMPI function.

The effectiveness of KCP is influenced by various facets of organization culture like human relationships, degree of harmony between decision-making entities, quality of work process, strategic alliance with vendors, customers' trust, effectiveness of strategic management, and CEO's character and vision, etc., all of which in turn influence the management performance. Therefore, the proposed KMPI can be used to represent the KM performance. We assume that KCP has always been continuing since the firms started, and that organizational knowledge increases as KCP supports management activities from the knowledge-based perspective.

Tuomi (2000) suggests a reversed hierarchy of knowledge in which organizational knowledge is created after knowledge from which information is given meaning, and data emerge as a byproduct of cognitive artifacts. The proposed KMPI increases only if the KCP efficiency is improved, which is theoretically supported by Tuomi (2000)'s argument in that the existence of knowledge can create a form of competence and organizational knowledge, and management performance may be enhanced.

At this point, let us investigate the five components of KCP to clearly understand why the proposed KMPI can represent the quality of organizational knowledge, and the firm's management performance. The first component of KCP is knowledge creation which is concerned with creating a variety of knowledge, tacit or explicit. Knowledge creation is accelerated by massive synergistic interrelations of a lot of individuals having diverse backgrounds. Knowledge accumulation is a second knowledge flow component of KCP, which is stored into a knowledge repository. All the individuals in firms can have access to it to get relevant knowledge for their works or decision problems. Especially, the knowledge accumulated in firms for years can play an important role in eliminating various obstacles and inefficiencies and improving management performance, which is then called organizational knowledge (Walsh and Ungson, 1991). However, if knowledge created through management activities for years is not accumulated systematically either in electronically deliverable formats (O'Leary, 1988abc) or in structured documents, it cannot be used usefully for future decision-making needs. In this respect, knowledge created in various reasons and ways and forms should be accumulated in a form of organizational memory information systems (Stein and Zwass, 1995). Third component of KCP is knowledge sharing which promotes diffusion of knowledge in firms, and also contributes to making work process an intelligent and knowledge-intensive. In this situation, workers feel themselves so called *knowledge worker* (Sviokla, 1996). If knowledge workers can find knowledge necessary for processing their works successfully from the knowledge source administered by firms, then they are able to easily apply it to complete such works successfully. The knowledge-intensive work process requires integration of multiple knowledge much more for obtaining improved performance (Davenport et al., 1996). Knowledge utilization, fourth component of KCP, may be observed and performed in all the levels of management activities in firms. As the work processes need to become more knowledge-intensive in the aftermath of applying KM, one of the popular forms of knowledge utilization is to adopt best practice from other leading firms and find some knowledge relevant to us and apply it (O'Dell and Grayson, 1998). The fifth component of KCP is knowledge internalization which may occur when individual workers find some knowledge relevant to their works, and apply and obtain what they expect. Therefore, knowledge internalization may give rise to another knowledge, either new or modified one. In this way, knowledge internalization is providing a basis for more active knowledge creation. Nonaka and Konno (1998) suggest a concept of *Ba* where knowledge can be internalized more easily and created after all.

Based on the arguments above, the whole process of KCP is cycling from knowledge creation to knowledge accumulation to knowledge sharing to knowledge utilization to knowledge internalization. Knowledge accumulated in firms is a byproduct of KCP. Therefore, KCP has a concept of flow, and speed. If the flowing speed of KCP is fast, then we may assume that knowledge, its byproduct, is accumulated, shared, utilized, and internalized as fast, and that management performance increases, and that the proposed KMPI will improve after all.

In this way, KCP has an influence on the efficiency of work processes, and management activities performance. Based on the argument about KCP characteristics above, we claim that KMPI, which is assumed to be heavily influenced by KCP, can measure the quality of organizational knowledge, and that it is related directly and/or indirectly with firms' management performance. Therefore, we hypothesize that such firms with organizational knowledge of a good quality, will increase KMPI, and that those firms with greater KMPI will represent improved management performance. We adopt three specific measures like stock price, PER, R&D expenditure to translate management performance into tangible statistics. Then we can posit the following three research hypotheses.

Hypothesis 1: If KMPI is greater, then stock price is significantly better.
Hypothesis 2: If KMPI is greater, then PER is significantly better.
Hypothesis 3: If KMPI is greater, then R&D expenditure is significantly better.

3.2 KMPI Function

As knowledge beneficial to making work processes knowledge-intensive and improving management performance is accumulated in organization, then organization memory quality will increase with time, causing KMPI to increase gradually with an upper limit. The increase in KMPI per unit time is small at first, then increases rapidly and finally slows down. This rational can be described as follows. As workers learn to get accustomed to KCP - creating, accumulating, sharing, utilizing, and internalizing knowledge- in processing their works and integrate it with existing operations, the rate at which KMPI increase is small. The rate then increases as workers become familiar with applying KCP to their work processes. However, the rate slows down as KMPI approaches the limit of what can be gained from applying KCP to works. Stated formally, the impact of KCP application at time *t* is proportional to the KMPI gained at time *t-1* (i.e., $KMPI_{t-1}$) relative to the maximum possible KMPI gains from the KCP application (i.e., 1) and the remaining KMPI yet to be gained (i.e., $1\text{-}KMPI_{t-1}$). This description of KMPI over time *t* can be expressed as

$$\frac{dKMPI}{dt} = -KCP(1 - KMPI_{t-1}) \quad \text{(Eq 1)}$$

where KCP indicates a term denoting efficiency of KM in organization, which can be described as a function of five knowledge circulation processes. Solving (Eq 1) for KMPI yields

$$KMPI_t = \frac{1}{1 + e^{a+KCP \cdot t}} \quad \text{(Eq 2)}$$

Equation 2 is the S-shaped logistic model, where 1 is the upper bound on the KMPI from the KCP application, while *a* and *KCP* determine the shape of the curve. We assume that constant a is zero because each organization is supposed to start with very small KMPI. Then next step for calculating KMPI is to compute KCP which will be described empirically in the next section. Therefore, final equation form for KMPI is as follows.

$$KMPI_t = \frac{1}{1 + e^{KCP \cdot t}} \quad \text{(Eq 3)}$$

As noted previously, we suppose that KCP term in (Eq 3) is determined by five knowledge circulation processes. Stated empirically, KCP term in (Eq 3) is a function of *relative weight of eigenvalue* (RWE) of each knowledge circulation component multiplied by *average factor value* (AFV) of the corresponding knowledge circulation component.

$$KCP = RWE_{KC} \cdot AFV_{KC} + RWE_{KA} \cdot AFV_{KA} + RWE_{KS} \cdot AFV_{KS} + RWE_{KU} \cdot AFV_{KU} + RWE_{KI} \cdot AFV_{KI} \quad \text{(Eq 4)}$$

where KC means knowledge creation, KA knowledge accumulation, KS knowledge sharing, KU knowledge utilization, and KI knowledge internalization. How to compute RWE and AFV will be described in the next section from an empirical perspective.

4. THE EMPIRICAL STUDY

4.1 Survey Instrument Development

The process of designing the survey is notably influenced by Churchill (1979)'s recommendations for developing reliable and valid measures. Initially, questionnaire with 40 questions was prepared relating to five components of KCP. Open-ended interviews were used in the initial stages of instrument development. Two professors and four doctoral candidates and two practitioners, all of whom have been studying or practicing KM for years, were interviewed to ensure the questionnaire variables' face validity. Discussions with two KM professors on each variable helped in developing operational measures. Upon completion of the interviews, a pretest was conducted in which 18 executives from 18 companies were asked individually to evaluate the instrument and comment on the clarity of instructions and understandability of individual items. All of them responded, and based on the feedback received, 7 items were deleted from original 40 items. We concluded after evaluation that questionnaire using a seven-point scale, ranging from 1: "strongly disagree" to 4: "neutral" to 7: "strongly agree", is appropriate for measuring KMPI as intended in research design.

4.2 Data Collection

A cross-sectional field survey of companies in KOSDAQ market in Korea was conducted. A directory of companies compiled by a securities brokerage firm operating in a stock market was used as the sampling frame. This directory consists of organizations that at least one of the following three criteria:
(1) They were members of the KOSDAQ market.
(2) Their operating years are similar to each other because our definition of KM, causing KCP application to start with the foundation of company and then KMPI to increase gradually from company inauguration date, requires the almost same years of operation to avoid biases in measuring KMPI. Since KOSDAQ market opened in 1996, those companies surveyed have almost same five years of operation.
(3) They reported annual financial reports officially in line with formal official accounting standards imposed by KOSDAQ market.
A senior executive of each organization surveyed was asked to respond to questionnaire. While using a single source from each organization has its limitations, these are overcome to some degree by identifying the senior executive as executives most "informed" about KM and KCP and associated variables within each organization. A similar use of the "key informant" approach has been suggested for survey research and has been adopted by several IS researchers (Sethi and King, 1991). Surveys were sent to senior executives in 250 randomly selected organizations which met three criteria above. 101 usable responses were received, providing a response rate of 40.4 percent.

4.3 Sample Description

Table 3 provides a profile of the respondents by the number of full-time employees and sales volume. All sizes are well represented in our study example.

Table 3. Distribution of Respondents

(a) Distribution by Sales volume

Sales Volume (Unit: $1,000)	No. of Respondents	Percentage
$1,000 ≤	16	15.9
$1,000 – $10,000	28	27.7
$10,000 - $100,000	42	41.5
≥ $100,000	15	14.9
Total	101	100%

(b) Distribution by Full-time Employees Size

No. of full-time employees	No. of Respondents	Percentage
20 ≤	18	17.8
20 – 50	37	36.6
50 – 100	35	34.7
≥ 100	11	10.9
Total	101	100%

Table 4. Factor Structure of variables (N=101)

Factor	Eigenvalue	Cronbach's Alpha	Items	Factor loadings	Convergent validity
Knowledge Utilization	4.1307	0.86	There exist research and education programs	0.8002	0.86
			Team work is promoted by utilizing organization-wide information and knowledge	0.6437	0.68
			EDI is extensively used to facilitate processing tasks	0.6179	0.72
			There exist incentive and benefit policies for new ideas suggestion through utilizing existing knowledge	0.5327	0.67
			There exists a culture encouraging knowledge sharing	0.5199	0.71
			Work flow diagrams are required and used for performing tasks	0.5095	0.68
Knowledge Accumulation	4.1092	0.83	We refer to corporate database before processing tasks	0.7164	0.62
			We try to store know-how about new tasks design and development	0.6817	0.65
			We try to store legal guidelines and policies related to tasks	0.6729	0.69
			We extensively search through customer database and task-related database to obtain knowledge necessary for tasks	0.5687	0.66
			We document such knowledge needed for tasks	0.5524	0.81
			We summarize education results and store them	0.5400	0.65
			We are able to administer knowledge necessary for tasks systematically and store it for further usage	0.5081	0.85
Knowledge Internalization from-1	3.2388	0.77	I have a unique know-how for tasks	0.7134	0.72
			Professional knowledge such as customer knowledge and demand forecasting is managed systematically	0.6444	0.60
			Organization-wide standards for information resources are built	0.6211	0.71
			Employees are given education opportunity to improve adaptability to new tasks	0.5957	0.66
			University-administered education is offered to enhance employees' ability to perform tasks	0.5695	0.75
			Organization-wide knowledge and information are updated regularly and maintained well	0.5036	0.70
Knowledge Internalization from -2	2.4825	0.78	I can learn knowledge necessary for new tasks	0.6997	0.63
			I can refer to best practices and apply them to my tasks	0.6527	0.62
			I can use Internet to obtain knowledge for tasks	0.5633	0.69
Knowledge Sharing	2.3504	0.75	We share information and knowledge necessary for tasks	0.8760	0.64
			We improve task efficiency by sharing information and knowledge	0.7751	0.73
			We developed information systems like intranet and electronic bulletin board to share information and knowledge	0.7178	0.71
			We promote sharing necessary information and knowledge with other teams	0.5422	0.61
Knowledge Creation-1	2.3379	0.72	I often use an electronic bulletin board to analyze tasks	0.6434	0.62
			Predecessor gave me detailed introduction on my tasks	0.6246	0.64
			I fully understand core knowledge necessary for my tasks	0.5521	0.66
Knowledge Creation-2	2.0096	0.70	I obtain useful information and suggestions through idea-brainstorming meeting without spending too much time	0.7505	0.63
			I search information for tasks from various knowledge sources administered by organization	0.5628	0.67
			I understand computer programs needed to perform tasks and use them well	0.5482	0.64
			I am ready to accept new knowledge and apply it to my tasks when necessary	0.5321	0.71

4.4 Measures

4.3.1 Knowledge Creation

To measure knowledge creation, two constructs were operationalized-tasks understandings and information understandings. Tasks understandings are measured by three items (Nonaka and Takeguchi, 1995; Tuomi, 2000)– (1) I often use an electronic bulletin board to analyze tasks, (2) Predecessor gave me detailed introduction on my tasks, (3) I fully understand core knowledge necessary for my tasks. Information understandings are measured by four items (Leonard and Sensiper, 1998; Saint-Onge, 1998)– (4) I obtain useful information and suggestions through idea-brainstorming meeting without spending too much time, (5) I am ready to

Table 5. Average Factor Value

Organization	KC	KA	KS	KU	KI
com1	0.391	-0.679	-0.298	-0.312	0.350
com2	-0.781	0.197	0.554	0.477	1.057
com3	0.025	0.097	1.322	-1.707	-1.699
com4	2.383	1.498	0.473	1.848	0.590
com5	0.967	-0.616	-0.601	-1.111	0.378
com6	-0.282	-0.771	0.675	-0.650	-0.266
com7	0.784	-0.093	-0.348	-0.676	-0.706
com8	0.194	-1.387	0.280	0.259	0.010
com9	0.314	0.423	-1.255	-1.036	-1.151
com10	-0.854	0.441	0.377	1.067	-0.314
com11	0.497	-1.558	-1.433	-0.892	-0.416
com12	0.714	0.486	0.928	1.255	-1.664
com13	-1.061	-0.205	0.058	0.585	0.612
com14	0.626	-0.707	0.384	-0.328	0.342
com15	1.783	-2.509	-0.515	1.414	-1.225
com16	-0.175	-0.187	0.049	-1.550	0.005
com17	-1.975	-0.442	-0.554	2.191	1.447
com18	1.214	0.783	-0.027	-0.565	-0.935
com19	0.376	0.644	-0.560	0.171	-0.089
com20	1.884	-0.754	0.107	0.010	0.071
com21	0.188	0.520	0.200	-1.790	-0.272
com22	1.362	0.176	-0.261	-0.035	-0.235
com23	0.436	0.217	-0.140	-0.004	1.086
com24	-0.762	1.295	-0.483	-0.658	-0.539
com25	2.790	1.023	1.026	1.564	0.550
com26	-0.239	-0.160	-0.002	-0.572	0.190
com27	0.936	-0.331	-0.156	0.772	-0.115
com28	0.576	0.138	1.032	0.700	-0.970
com29	-0.219	1.522	-0.184	1.400	0.568
com30	0.421	-0.242	0.274	-1.683	-0.668
com31	-0.227	0.338	-0.095	-0.972	0.612
com32	0.281	0.383	-0.865	0.071	0.421
com33	-0.537	-0.030	1.399	0.236	-0.604
com34	-1.231	0.292	-1.051	0.006	-0.163
com35	-0.596	0.408	-1.475	0.479	1.008
com36	0.473	-0.451	-0.222	-1.954	-0.049
com37	-0.242	0.445	1.372	0.928	0.660
com38	-0.024	-1.048	0.696	0.308	-1.125
com39	-1.018	-0.071	-0.508	0.734	0.944
com40	-0.279	-0.153	0.574	-0.443	0.017
com41	-0.906	-0.912	0.516	0.279	0.373
com42	-0.041	-0.145	-0.811	-0.016	-0.376
com43	1.925	-0.061	0.492	1.539	0.538
com44	0.227	0.759	-1.805	-0.174	-0.236
com45	-0.219	-0.651	-0.117	-0.200	0.137
com46	-0.040	0.143	-0.373	-0.842	0.251
com47	-0.360	0.905	0.384	0.661	-0.081
com48	1.229	-0.444	1.324	-1.886	-1.024
com49	0.644	0.644	-0.012	0.278	0.020
com50	-0.757	0.087	0.434	0.244	-0.878
com51	0.202	-1.643	-0.344	0.155	-0.416
com52	0.936	0.263	0.320	1.159	0.239
com53	-1.146	-0.486	-0.858	0.028	-0.050
com54	0.098	0.847	0.197	0.319	-0.380
com55	0.238	0.858	-0.578	1.054	0.270
com56	0.601	0.767	0.396	0.683	0.430
com57	-0.855	0.783	1.277	-0.612	0.218
com58	-0.601	0.485	-0.181	0.219	-0.162
com59	0.723	-0.579	-0.481	0.684	-0.560
com60	-0.526	-1.552	0.146	-0.390	-0.578
com61	-0.765	-0.337	0.152	-0.529	0.879
com62	-1.154	-0.057	0.484	0.331	0.021
com63	1.004	1.000	0.504	1.113	-0.319
com64	2.271	0.370	-0.258	3.554	-0.484
com65	-1.412	0.650	0.332	0.512	-0.930
com66	0.971	0.808	-0.972	0.796	0.523
com67	-0.943	-0.006	0.099	-0.790	0.299
com68	-1.161	-0.439	0.821	-0.167	-0.156
com69	-0.933	-0.316	1.312	-1.421	1.028
com70	0.813	-0.238	1.197	-0.856	0.077
com71	0.627	0.440	0.055	1.067	0.994
com72	-0.516	0.070	-0.049	0.187	-1.063
com73	0.715	0.713	0.224	0.083	0.190
com74	1.601	-0.639	-0.466	-0.635	-0.588
com75	-2.969	0.367	0.810	-1.289	-1.195
com76	0.079	0.400	0.249	0.050	-0.220
com77	0.752	-0.721	0.912	1.052	0.906
com78	0.736	0.572	0.298	0.451	0.572
com79	0.590	0.264	-0.682	0.147	0.994
com80	0.637	0.734	0.069	-0.583	1.068
com81	-1.743	-0.114	-0.875	-1.391	-0.759
com82	0.627	0.440	0.055	1.067	0.994
com83	-2.969	0.367	0.810	-1.289	-1.195
com84	0.079	0.400	0.249	0.050	-0.220
com85	0.590	0.264	-0.682	0.147	0.994
com86	0.637	0.734	0.069	-0.583	1.068
com87	0.644	0.644	-0.012	0.278	0.020
com88	0.238	0.858	-0.578	1.054	0.270
com89	-0.526	1.614	0.146	-0.390	0.564
com90	0.436	0.217	-0.140	-0.004	1.086
com91	0.936	-0.331	-0.156	0.772	-0.115
com92	-0.227	0.338	-0.095	-0.972	0.612
com93	-0.282	-0.771	0.675	-0.650	-0.266
com94	0.714	0.486	0.928	1.255	-1.664
com95	1.214	0.783	-0.027	-0.565	-0.935
com96	-0.041	-0.145	-0.811	-0.016	-0.376
com97	1.925	-0.061	0.492	1.539	0.538
com98	-0.297	0.759	-1.805	-0.174	0.288
com99	-1.146	-0.486	-0.858	0.028	-0.050
com100	0.098	0.847	0.197	0.319	-0.380
com101	-0.540	-1.048	0.696	0.308	-1.125

accept new knowledge and apply it to my tasks when necessary, (6) I understand computer programs needed to perform tasks and use them well, (7) I search information for tasks from various knowledge sources administered by organization.

Table 6. Relative Weight of Eigenvalue (RWE)

Factor	Eigenvalue	RWE
Knowledge Creation	4.348	0.211
Knowledge Accumulation	4.110	0.199
Knowledge Sharing	2.350	0.114
Knowledge Utilization	4.131	0.200
Knowledge Internalization	5.722	0.276
Total	20.661	1

4.3.2 Knowledge Accumulation

An instrument knowledge accumulation was tested by three constructs – database utilization, systematic management of task knowledge, and individual capacity for accumulation. Database utilization was operationalized by two items (O'Leary, 1998abc; Tuomi, 2000)- (1) We refer to corporate database before processing tasks, (2) We extensively search through customer database and task-related database to obtain knowledge necessary for tasks. Systematic management of task knowledge was operationalized by three items- (3) We try to store know-how about new tasks design and development, (4) We try to store legal guidelines and policies related to tasks, (5) We are able to administer knowledge necessary for tasks systematically and store it for further usage. Individual capacity for accumulation was operationalized by two items- (6) We document such knowledge needed for tasks, (7) We summarize education results and store them.

4.3.3 Knowledge Sharing

Degree of sharing knowledge is dependent upon constructs such as core knowledge sharing and knowledge sharing in organization. Core knowledge sharing was measured by two items (Lank, 1997; Sviokla, 1996)- (1) We share information and knowledge necessary for tasks, (2) We improve task efficiency by sharing information and knowledge. Knowledge sharing in organization was operationalized by two items (Davenport et al., 1996; Ruggles, 1998)- (3) We promote sharing necessary information and knowledge with other teams, (4) We developed information systems like intranet and electronic bulletin board to share information and knowledge.

4.3.4 Knowledge Utilization

Knowledge utilization depends on two constructs- degree of knowledge utilization in organization, and knowledge utilization culture. The former was operationalized by three items (O'Dell and Grayson, 1998; Weber et al., 1990; Blanning and Daivd, 1995)- (1) Team work is promoted by utilizing organization-wide information and knowledge, (2) EDI is extensively used to facilitate processing tasks, (3) Work flow diagrams are required and used for performing tasks. The latter was operationalized by three items (Leonard and Sensiper, 1998; Wiseman, 1988)- (4) There exists a culture encouraging knowledge sharing, (5) There exist incentive and benefit policies for new ideas suggestion through utilizing existing knowledge, (6) There exist research and education programs.

4.3.5 Knowledge Internalization

Knowledge internalization was measured by three constructs- capability to internalize task-related knowledge, education opportunity, level of organization learning. Capability to internalize task-related knowledge was operationalized by four

Table 7. KMPI Calculation

Organization	KMPI	Organization	KMPI	Organization	KMPI	Organization	KMPI
com4	0.800	com49	0.580	com95	0.509	com24	0.441
com25	0.798	com87	0.580	com13	0.507	com67	0.434
com64	0.750	com89	0.576	com31	0.496	com21	0.434
com43	0.712	com20	0.570	com92	0.496	com65	0.429
com97	0.712	com17	0.567	com59	0.491	com50	0.429
com71	0.671	com47	0.564	com58	0.487	com68	0.422
com82	0.671	com27	0.559	com1	0.487	com48	0.416
com29	0.662	com91	0.559	com98	0.482	com6	0.416
com63	0.646	com22	0.555	com61	0.481	com93	0.416
com52	0.642	com54	0.543	com33	0.480	com72	0.412
com56	0.641	com100	0.543	com5	0.474	com34	0.410
com77	0.641	com32	0.542	com44	0.473	com16	0.407
com37	0.637	com35	0.540	com40	0.473	com38	0.405
com66	0.636	com19	0.538	com69	0.472	com51	0.400
com78	0.634	com12	0.536	com46	0.470	com36	0.397
com80	0.615	com94	0.536	com62	0.468	com53	0.391
com86	0.615	com28	0.535	com74	0.467	com99	0.391
com55	0.608	com39	0.530	com26	0.464	com30	0.390
com88	0.608	com70	0.528	com8	0.463	com101	0.379
com23	0.603	com10	0.519	com41	0.461	com9	0.373
com90	0.603	com76	0.518	com45	0.452	com3	0.346
com79	0.599	com84	0.518	com7	0.445	com60	0.345
com85	0.599	com14	0.516	com42	0.441	com11	0.340
com73	0.596	com57	0.515	com96	0.441	com81	0.273
com2	0.580	com18	0.509	com15	0.441	com75	0.259

items- (1) I have a unique know-how for tasks, (2) I can learn knowledge necessary for new tasks, (3) I can use Internet to obtain knowledge for tasks, (4) I can refer to best practices and apply them to my tasks. Education opportunity was operationalized by two items- (5) Employees are given education opportunity to improve adaptability to new tasks, (6) University-administered education is offered to enhance employees' ability to perform tasks. Level of organization learning was operationalized by three items- (7) Professional knowledge such as customer knowledge and demand forecasting is managed systematically, (8) Organization-wide standards for information resources are built, (9) Organization-wide knowledge and information are updated regularly and maintained well.

4.5 Data Analyses Procedure

Preliminary factor analysis of items in each of the constructs validated the measures that were later used in the KMPI calculation model (Eq 3) and (Eq 4). Exploratory factor analysis was adopted with orthogonal rotation method (Hair et al., 1998). Seven factors were found with cronbach alpha value being greater than 0.7, which indicates that internal consistency is guaranteed in each factor dimension. Table 4 shows factor structure of variables, where reliability and convergent validity are significant because cronbach's alpha is greater than or equal to 0.70, and all convergent validity is greater than 0.60 (Hair et al., 1998). Table 5 and 6 summarize RWE and AFV, all of which are required to calculate KMPI shown in Table 7. Table 8 shows correlation test between KMPI and three financial measures. Hypotheses 1 and 2 are proved with 0.1 significance level, while hypothesis 3 is proved with 0.05 significance level.
The empirical results in Tables 4 through 7 show that as theorized, those five components of KCP affect KMPI significantly, which in turn represents the quality of organization memory that is utilized in a wide variety of decision-makings in an organization. If the quality of organization memory is good, then we can easily conjecture that management performance improves significantly.

Table 8. Correlation between KMPI and Three Financial Measures

Financial Measures	Correlation with KMPI
Stock Price	0.233*
PER	0.213*
R&D Expenditure	0.259**

*: p<0.1, **: p<0.05

5. CONCLUDING REMARKS

In this paper, we have presented a discussion of a close relationship between KMPI and KCP. Our study shows that there is no tension between the effects of KCP and KMPI. As the efficiency of five components of KCP increases, then KMPI becomes greater through the logistic model. Those five components of KCP are knowledge creation, knowledge accumulation, knowledge sharing, knowledge utilization, and knowledge internalization. Based on a review of a broad range of relevant literature, several conclusions may be drawn from our study.
(1) Extensive literature review revealed the complexity and multi-faceted nature of organizational knowledge and KM, and the need for developing a new measurement metric to assess the KM performance. To deal with complex nature of organizational knowledge and its contribution to KM performance, we introduced a concept of KCP and applied it to devise a function of KMPI.
(2) KMPI function is basically a logistic model in which the contribution of organizational knowledge accumulated by performing KM for years starts with a slow growth rate and increases fast and slows down at some point in time to a mature level.
(3) Power of KMPI to represent financial performance of firms was tested statistically. We used three major financial indices such as stock price, PER, and R&D expenditure. We proved that correlation between KMPI and those three indices is statistically significant.
IT has a strong impact on the effectives of five components of KCP. Especially, the Internet may become a crucial factor for making KMPI successful because the Internet use in daily management activities renders normal and essential. Based on this prospect, it is necessary to investigate the potential contribution of the Internet and consider it in improving the KMPI. We hope that this study may trigger future researches in this challenging field of evaluating the KM performance.

ACKNOWLEDGMENT

This study was supported by Korea Research Foundation Grant. (KRF-99-005-C00002)

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