A Review of Metrics for Knowledge Management Systems and Knowledge Management Initiatives

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Abstract

Metrics are essential for the advancement of research and practice in an area. In knowledge management (KM), the process of measurement and development of metrics is made complex by the intangible nature of the knowledge asset. Further, the lack of standards for KM business metrics and the relative infancy of research on KM metrics points to a need for research in this area. This paper reviews KM metrics for research and practice and identifies areas where there is a gap in our understanding. It classifies existing research based on the units of evaluation such as user of KMS, KMS, project, KM process, KM initiative, and organization as a whole. The paper concludes by suggesting avenues for future research on KM and KMS metrics based on the gaps identified.

1. Introduction

Knowledge management (KM) has become an accepted part of the business and academic agenda. Organizations have high expectations for KM to play a significant role in improving their competitive advantage [35]. Measuring the business value of KM initiatives has become imperative to ascertain if the expectations are realized.

Metrics are measures of key attributes that yield information about a phenomenon [45]. Metrics are key to advancement of research and practice in an area. In research, they provide comparability of studies between individuals, time-periods, organizations, industries, cultures, and geographic regions [14]. They also provide a basis for empirical validation of theories and relationships between concepts. Measures that are reliable and valid enable cumulation of research in a topic area and free subsequent researchers from the need to redevelop instruments [10].

For practitioners, metrics are a way of learning what works and what does not. In fact, measuring business performance is the focus of the entire field of management accounting. In KM, performance measures serve several objectives including securing funding for KM implementation, providing targets and feedback on implementation, assessing implementation success, and deriving lessons for future implementation. Measures can assist in evaluating the initial investment decision and in developing benchmarks for future comparison.

Measurement is typically a complex process fraught with errors. What is easy to measure is not always important and what is important is often difficult to measure [42]. KM metrics are particularly distinct from other metrics due to the intangible nature of the knowledge resource [18]. Something such as knowledge that is difficult to define and has multiple interpretations is likely to be difficult to value and measure. Due to such considerations and the complexity of assessing organizational initiatives in general, research [22] and practice [9] on the assessment of KM initiatives and knowledge management systems (KMS) is not well developed.

In light of the above motivations, this study seeks to review metrics in practice and research and identify areas for further investigation. Previous research on metrics for KM and KMS is classified based on the elements of evaluation such as user of KMS, KMS, project, KM process, KM initiative, and organization as a whole. The paper concludes by providing avenues for future research based on the gaps identified during the review. In the next section, some basic definitions of metrics and KMS are provided. This is followed by the review of practice KM metrics, classification of research on KMS and KM metrics, and finally a discussion of areas for further investigation.

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2. Definitions

2.1. Metrics and measures

At the outset it is important to distinguish what is meant by a metric and a measure. The IEEE standard glossary of software engineering provides the following definitions of measures and metrics. A *measure* is a standard, unit, or result of measurement [28]. A *metric* is a quantitative measure of the degree to which a system, entity, or process possesses a given attribute [29]. Without a trend to follow or an expected value to compare against, a measure gives little or no information. It especially does not provide enough information to make meaningful decisions. A metric is a comparison of two or more measures. Therefore, a measure by itself doesn't provide much understanding unless it is compared with another value of the measure i.e., it becomes a metric. Hence the focus of our review is on metrics for KMS and KM initiatives.

2.2. KM and KMS

KM involves the basic processes of creating, storing and retrieving, transferring and applying knowledge. The ultimate aim of KM is to avoid reinventing the wheel and leverage cumulative organizational knowledge for more informed decision-making. Examples of ways in which knowledge can be leveraged include: transfer of best practices from one part of an organization to another part, codification of individual employee knowledge to protect against employee turnover, and bringing together knowledge from different sources to work on a specific project.

Information technology (IT) is recognized as a key enabler of KM (although there are many other factors that are necessary for KM success). Without the capabilities of IT in terms of both storage and communication, leveraging of knowledge resources would hardly be feasible. A variety of tools are available to organizations to facilitate the leveraging of knowledge. These tools (KMS) are defined as a class of information systems applied to managing organizational knowledge. That is, they are IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application [3].

Common KMS technologies include intranets and extranets, search and retrieval tools, content management and collaboration tools, data warehousing and mining tools, and groupware and artificial intelligence tools like expert systems and knowledge-based systems.

Two models of KMS have been identified in information systems research [2] both of which may be employed by organizations to fulfill different needs. These two models correspond to two different approaches to KM i.e., the codification approach and the personalization approach [25] (these two models have alternately been labeled as integrative and interactive architectures respectively [52]). The *repository* model of KMS associated with the *codification* approach focuses on the codification and storage of knowledge in knowledge bases. The purpose is to facilitate knowledge reuse by providing access to codified expertise. Electronic knowledge repositories (EKR) to code and share best practices exemplify this strategy [3]. A related term, organizational memory information system (OMIS) refers to any system that functions to provide a means by which knowledge from the past is brought to bear on the present in order to increase levels of effectiveness for the organization [43].

The *network* model of KMS associated with the *personalization* approach attempts to link people to enable the transfer of knowledge. One way to do this is to provide pointers to location of expertise in the organization i.e., who knows what and how they can be contacted. This method is exemplified by knowledge directories, commonly called “yellow pages” [3]. It has been noted that in order to access the knowledge in an organization that remains uncodified, mapping the internal expertise is useful [40].

A second way is to link people who are interested in similar topics. The term communities of practice (COP) has come into use to describe such flexible groups of professionals informally bound by common interests who interact to discuss topics related to these interests [12]. KMS that provide a common electronic forum to support COP exemplify this approach [3]. The two models of KMS allow us to make sense of existing KMS metrics (since metrics for a particular type of KMS are similar) and identify directions for further evaluation of KMS.

3. KM and KMS metrics in practice

3.1. KM Metrics

Most practice metrics of KM initiatives focus on measuring knowledge assets or intellectual capital (IC) of a firm, assuming the outcome of a KM initiative being its impact on IC. Majority of respondents of practice surveys think that IC should be reported and knowledge measurement would improve performance [9]. Even the process of measuring IC is considered important whether as an internal management tool or

for external communication on financial balance sheets.

Three general purpose approaches to measuring the impact of KM initiatives include House of Quality (Quality Function Deployment or QFD), Balanced Scorecard, and American Productivity Center (APQC) benchmarking approach [48]. The House of Quality [26] method involves the development of a metrics matrix (house). The desirable outcomes of KM initiatives are listed on the left wall of the house, the roof consists of the performance metrics, the right wall consists of the weights (relative importance of the outcomes), and the base of the house consists of targets, priorities, and benchmark values. By looking at the correlations within the body of the matrix, management can decide to focus on those areas of KM that are most likely to affect overall firm performance. A number of software tools such as QFD designer are available to automate the analysis process.

The Balanced Scorecard technique developed by Kaplan and Norton [32] aims to provide a technique to balance long-term and short-term objectives, financial and non-financial measures, leading and lagging indicators, and internal and external perspectives. Typically four views i.e., customer, financial, internal business, and learning and growth, are used to translate high level strategies to real targets. Within each view, the goals, metrics, targets, and initiatives are listed. Relationships between views must also be considered. The views (dimensions) can be suitably adapted to assess current state of KM and evaluate the impact of initiatives in this area. Here also software tools are available though in general the balanced scorecard is more difficult to develop than QFD. However it is likely to yield more "balanced" goals with an in-built consideration of the causal relationships.

The APQC process classification framework (PCF) provides a detailed taxonomy of business processes derived from the joint effort of close to 100 U.S. businesses [5]. The PCF can be employed to benchmark and assess impact on business processes as a result of introduction of KM initiatives. Other general measures of firm performance such as Economic Value Added (EVA) and Tobin Q can also be used for evaluating IC [44].

Three other metrics specific to KM are the Skandia Navigator, IC index, and Intangible Assets Monitor. The Skandia Navigator [17] consists of 112 IC and traditional metrics (with some overlap between metrics) in five areas of focus (financial, customer, process, renewal and development, human). These areas are similar to the balanced scorecard views except for the additional human focus area in the Skandia metric (more areas can also be added in Balanced Scorecard as desired, though a limit of 7 areas is suggested). Out of all the indicators, the monetary indicators are combined into a single dollar value C while the remaining percentage completeness measures are combined into an efficiency indicator I which captures the firm's velocity or movement towards desired goals. The overall IC measure is a multiplication of I and C.

The IC index [39] is an extension to the Skandia IC metric that attempts to consolidate measures into a single index and correlate this index with changes in the market i.e., it focuses on monitoring the dynamics of IC. It consists of monitoring both IC stock and IC flow. A third technique is the Intangible Assets Monitor [46]. Intangible asset value is defined as the book value of the firm minus the tangible assets and the visible debt. Three components of intangible assets are external structure (brand, customer and supplier relations), internal structure (management, legal, manual, attitude, software), and individual competence (education, experience, expertise). For each intangible asset component, three indicators focus on growth and renewal, efficiency, and stability of that component. Other KM specific techniques include Technology Broker [11] and Citation-weighted Patents [23].

Whether it is the more general purpose or the more KM specific techniques for business performance evaluation, the efficacy of all techniques depends on the competence of management in applying these techniques. Although the above-mentioned techniques attempt to provide systematic and comprehensive indicators, there are a number of subjective judgments to be made in applying these techniques including determining which objectives are more important than others and which indicators need to be given greater weight. As pointed out in previous studies [9], a further limitation on these IC techniques is that many of them use different terms to label similar measures. A lack of standards leads to proliferation of measures and difficulty in comparison. Also, since most of the evidence on KM assessment is on a case by case basis, there is a lack of generalizable results on this topic.

3.2. KMS Metrics

Organizations employ a variety of metrics to assess their KMS [15]. System level measures for EKR include number of downloads, dwell time, usability surveys, number of users, number of contributions and seeks. Measures for electronic COP include number of contributions and seeks, frequency of update, number of members, and ratio of number of members to the number of contributors. System level measures have been used for evaluating and monitoring particular KMS implementations. Here also the literature is mainly in the form of individual case studies (for

example [51]) and generalizable measurement techniques are lacking.

4. Previous research on KM and KMS metrics

Researchers [22] have suggested a pragmatic framework for KM research based on the knowledge process and the context in which the process is embedded. The knowledge process can be divided into generation, codification, transfer, and realization. The elements of the embedded context include strategy, structure, people/culture, and technology. The framework can be applied for processes at individual, group, and organization levels. We adopt a similar classification for categorizing previous research on KM and KMS metrics based on elements of evaluation (user, system, project, process, and organization level).

4.1. User evaluation

The bulk of previous research at the user level has been studies to evaluate the motivation of users to contribute to or seek knowledge from different types of KMS and in a few studies the consequent usage of KMS (see Table 1).

Table 1. Selected studies on KMS users

Study	User	KMS	Sample
[13]	Contributor factors on seeker	Email distribution list	Tandem Computers
[20]	Contributor and seeker	Repository + electronic COP	Office equipment distributor
[30]	Contributor and seeker combined	All electronic media	1 University
[50]	More emphasis on contributor	Electronic COP	3 Usenet groups
[8]	Contributor	All electronic media	4 Public organizations

4.2. KMS evaluation

At the system level, a number of studies have attempted to develop performance criteria for different KMS. A summary of selected studies on this topic is provided in Table 2.

Table 2. Selected studies on KMS evaluation

Study	KMS	Performance Criteria	Sample
[1]	Answer Garden Knowledge repository (FAQ) + electronic COP (via email)	• Usage - heavy, intermittent, tire-kicker • User evaluation in seeking answer • Expert evaluation of providing answer	2 univ lab sites, 49 users (seeker), 7 experts (contributor)
[6]	Knowledge repository	Contributor • Simplicity, richness, flexibility of creation • Ease of consistency checking, ease of knowledge change management Seeker • Ease of knowledge navigation and searching Both • Awareness, timeliness, fairness	2 multi-media design teams
[31]	Organization memory information system	• Individual job time, number of assignments, completeness of solutions, quality of solutions, complexity of assignment, client satisfaction • Organizational unit capability (problem correct) Unplanned scrams (problem solve)	50 nuclear power plants
[27]	Knowledge-based system (expert system)	• Assessment of current knowledge • Establishment of strategic value of knowledge	17 organizations (government, bank, insurance, manufact-uring)

		• Comparison of knowledge to competition • Establishment of required knowledge • Creation of new knowledge • Distribution of knowledge • Application of knowledge • Evaluation of knowledge	
[38]	Koper Knowledge-based system	KM effects • Knowledge capture, organization and formalization • Knowledge distribution and application • Analytical consistency and completeness • Knowledge integration	Large multi-site enterprise
[21]	Data warehouse, executive IS, expert system, enterprise wide system, intranet	IT support for KM • Generating knowledge • Accessing knowledge • Transferring knowledge • Sharing knowledge • Codifying knowledge	73 law firms in Norway
[41]	Intranet implementa-tion	Level of implementation for knowledge sharing	44 organizations (different industries)
[36]	Knowledge management system	DeLone and McLean IS success model based criteria	

4.3. Project evaluation

Relatively fewer articles were found on KM metrics related to project evaluation (see Table 3). In the first study of the table the performance criteria are in terms of the knowledge process, whereas in the other two studies knowledge processes (sharing and creation) appear as mediators.

Table 3. Selected studies on project evaluation

Study	Project	Performance Criteria	Sample
[49]	Hypertext annual plan project	Efficiency index for knowledge utilization • Process width = number of employees • Process delay = time taken to spread / distribute • Process effort = time to document, distribute, and perceive use (not collect and compile)	Nokia telecom factory
[24]	New product develop-ment project	Project completion time (conception to market)	120 proj-ects in a large electron-ics company
[37]	Total quality manage-ment project	Project performance, goal achievement, ability to specify impact, change in attention rules	62 proj-ects in a Belgian multi-national steel wire manufactu rer

4.4. KM process and organizational level evaluation

A relatively popular area of research on KM and KMS metrics has been at the KM process and organizational level. Similar to the practice business performance metrics, the research metrics at this level also attempt to tease out the relationships between KM initiative, process, or capability, and firm performance albeit with a theoretical emphasis. Selected literature in this area is reviewed in Table 4.

5. Discussion and conclusion

From our literature review we can infer gaps in research on KM and KMS metrics. At the intersection of user and system level, there is a lack of research on usability of KMS and limited studies on usage of KMS. Both usability and usage studies if well designed

Table 4. Selected studies on organizational level KM evaluation

Study	Impact of	Performance Criteria	Sample
[33]	Overall KM initiative	KM effectiveness (organizational performance impacts)	185 KM practition-ers from discussion forums
[34]	KM initiative	Organization performance, customer satisfaction, ROI, shareholder value, reduced duplication of effort, employee satisfaction	Conceptual measures for individual, work unit, organizat-ion
[16]	Knowledge creation	Economic benefit • Worker competence (human capital) • Organization core competence • Task completion time and cost	Numerical example
[7]	Knowledge internaliz-ation, exte-rnalization, combinat-ion, social-ization + all KM tools use	KM satisfaction (availability, effectiveness of knowledge, KM at task, directorate, across organization, knowledge sharing)	Kennedy Space Center, 159 employees from 8 sub-units
[19]	KM capability: Knowledge infrastruc-ture, Knowledge process	• Organization effectiveness • Innovation and comm-ercialization, coordination of unit • Anticipate and identify opportunities • Speed and adaptation to market • Avoid redundancy and streamline	323 executives, finance and manufact-uring, large organizat-ions
[47]	IT knowledge relatedness	Market based performance Tobin's Q	315 firms, manufact-uring and service

can provide a good indicator of user acceptance of KMS. For example usability studies of both interactive and integrative KMS may be undertaken. Also, comparative studies of KMS usability may prove fruitful.

At the system level, the majority of studies appear to focus on EKR, OMIS, knowledge-based systems, and overall KM technologies. There appears to be a lack of evaluation studies on electronic COP since the majority of studies on COP appear to be anecdotal in nature. Therefore future research can investigate suitable metrics for evaluating electronic COP, an integral part of the network model of KMS. Further, review studies can help to infer commonalities and differences among the metrics for different forms of KMS.

There appears to be a relative paucity of KM evaluation studies at the group and team levels except for a few virtual team studies (e.g., [4]). Although there have been studies at the project level (see Table 3) which could be interpreted as group level evaluations, these studies did not investigate group characteristics and team dynamics in relation to evaluation of KM. This area presents an opportunity for future research on team effectiveness in terms of KM. For example, studies of how effective KMS are in terms of facilitating group, team, and project KM may be useful.

In relation to Grover and Davenport's framework [22], there appears to be a lack of studies focusing purposefully on evaluation of KM strategy and KM structure. Considering that both elements can be vital to the success of KM initiatives, research on these elements is required. Additionally there is a gap between the micro level assessment studies (user and system level) and the macro level assessment studies (organization level). Possibly more research on team, project, and business unit level KM evaluation may serve to bridge this gap. Aggregation from user and system level evaluation to team, project, and business unit level evaluation and subsequently to organization level KM evaluation could provide a worthwhile avenue for future research.

Although limited by the fact that a complete review of literature cannot be claimed, this study throws light on the existing research on KMS and KM metrics. It also serves to identify potential areas where further evaluation research would be useful. Given that organizations are expending significant resources towards implementing KM initiatives and KMS, more research on metrics in these areas is warranted.

6. References

[1] Ackerman, M. S. (1998). "Augmenting Organizational Memory: A Field Study of Answer Garden." *ACM Transactions on Information Systems* 16(3): 203-224.

[2] Alavi, M. and D. E. Leidner (1999). "Knowledge Management Systems: Issues, Challenges and Benefits." *Communications of AIS* 1: 1-37.

[3] Alavi, M. and D. E. Leidner (2001). "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues." *MIS Quarterly* 25(1): 107-136.

[4] Alavi, M. and A. Tiwana. (2002), 'Knowledge integration in virtual teams: The potential role of KMS', *Journal of the American Society for Information Science and Technology,* 53(12): 1029-1037.

[5] APQC (1998). Process Classification Framework, http://www.apqc.org/portal/apqc/site/generic2?path=/site/metrics/list_of_measures.jhtml

[6] Baek, S. and J. Leibowitz (1999). "Designing a Web-based Knowledge Repository in a Virtual Team and Exploring its Usefulness" *Americas Conference on Information Systems*, Milwaukee, Wisconsin.

[7] Becerra-Fernandez, I. and R. Sabherwal (2001). "Organizational Knowledge Management: A Contingency Perspective." *Journal of Management Information Systems* 18(1): 23-55.

[8] Bock, G. W. and Y. G. Kim (2002). "Breaking the Myths of Rewards: An Exploratory Study of Attitudes about Knowledge Sharing." *Information Resource Management Journal* 15(2): 14-21.

[9] Bontis, N. (2001). "Assessing Knowledge Assets: A Review of the Models used to Measure Intellectual Capital." *International Journal of Management Review* 3(1): 41-60.

[10] Boudreau, M., D. Gefen, and D.W. Straub (2001). "Validation in IS Research: A State-of-the-art Assessment." *MIS Quarterly* 25(1): 1-24.

[11] Brooking, A. (1996). *Intellectual Capital: Core Assets for the Third Millenium Enterprise*. London, Thomson Business Press.

[12] Brown, J. S. and P. Duguid (1991). "Organizational knowledge and communities of practice." *Organization Science* 2(1): 40-57.

[13] Constant, D., L. Sproull, and S. Kiesler (1996). "The kindness of strangers: The usefulness of electronic weak ties for technical advice." *Organization Science* 7(2): 119-135.

[14] Cook, T. D. and D. T. Campbell (1979). *Quasi-Experimentation: Design and Analysis Issues for Field Settings*. Boston, MA, Houghton Mifflin.

[15] DON (2001). Metrics guide for Knowledge Management Initiatives
http://www.km.gov/documents/DoN_KM_Metrics_Guide_Aug_01.pdf

[16] Edgington, T. M. and A. N. K. Chen (2002). "An Economic benefit Model for Knowledge Creation," *International Conference on Information Systems*, Barcelona.

[17] Edvinsson, L. and M. S. Malone (1997). *Intellectual Capital: Realizing Your Company's True Value by Finding its Hidden Brainpower*. New York, Harper Business.

[18] Glazer, R. (1998). "Measuring the Knower: Towards a Theory of Knowledge Equity." *California Management Review* 40(3): 175-194.

[19] Gold, A. H., A. Malhotra, and A.H. Segars (2001). "Knowledge Management: An Organizational Capabilities Perspective." *Journal of Management Information Systems* 18(1): 185-214.

[20] Goodman, P. S. and E. D. Darr (1998). "Computer-aided systems and communities: Mechanisms for organizational learning in distributed environments." *MIS Quarterly* 22(4): 417-440.

[21] Gottschalk, P. (2000). "Knowledge Management in the Professions: The Case of IT Support in Law Firms." *Hawaii International Conference on Systems Sciences*, Hawaii.

[22] Grover, V. and T. Davenport (2001). "General Perspectives on Knowledge Management: Fostering a Research Agenda." *Journal of Management Information Systems* 18(1): 5-22.

[23] Hall, B., A. Jaffe, and M. Trajtenberg (2000). "Market Value and patent Citations: A First Look." Cambridge, MA, NBER Working paper No. W7741.

[24] Hansen, M. T. (1999). "The Search-transfer Problem: The Role of Weak Ties in Sharing Knowledge across Organization Sub-units." *Administrative Science Quarterly* 44(1): 82-111.

[25] Hansen, M. T., N. Nohria, and T. Tierney (1999). "What's Your Strategy for Managing Knowledge?" *Harvard Business Review* 77(2): 106-116.

[26] Hauser, J. and L. Clausing (1988). "The House of Quality." *Harvard Business Review* 3: 63-73.

[27] Hendriks, P. H. J. and D. J. Vriens (1999). "Knowledge-based Systems and Knowledge Management." *Information and Management* 35: 113-125.

[28] IEEE (1983). "IEEE Standard Glossary of Software Engineering Terminology." *IEEE Std 729*.

[29] IEEE (1990). "IEEE Standard Glossary of Software Engineering Terminology." *IEEE Std 610.12*.

[30] Jarvenpaa, S. L. and D. S. Staples (2000). "The use of collaborative electronic media for information sharing: an exploratory study of determinants." *Journal of strategic information systems* 9(2-3): 129-154.

[31] Jennex, M., L. Olfman, P. Panthawi, and Y. Park (1998). "An Organizational Memory Information Systems Success Model: An Extension of DeLone and McLean's I/S Success Model." *Hawaii International Conference on Systems Sciences*, Hawaii.

[32] Kaplan, R. and D. Norton (1996). *Translating Strategy into Action: The Balanced Scorecard*. Boston, Harvard Business School Press.

[33] Khalifa, M., R. Lam, and M. Lee (2001). "An Integrative Framework for Knowledge Management Effectiveness." *International Conference on Information Systems*, New Orleans.

[34] King, W. R. and D. G. Ko (2001). "Evaluating Knowledge Management and the Learning Organization." *Communications of the Association for Information Systems* 5(14).

[35] KPMG (2000). Knowledge Management Research Report 2000.

[36] Maier, R. (2002). *Knowledge management systems: information and communication technologies for knowledge management*. Berlin, Springer.

[37] Mukherjee, A. S., M. A. Lapre, and L. Wassenhove (1998). "Knowledge Driven Quality Improvement." *Management Science* 44(11): S35-S49.

[38] Nissen, M. E. (1999). "Knowledge-based Knowledge Management in the Re-engineering Domain." *Decision Support Systems* 27: 47-65.

[39] Roos, J., G. Roos, N.C. Dragonetti, and L. Edvinsson (1998). *Intellectual Capital: Navigating in the New Business Landscape*. London, Macmillan.

[40] Ruggles (1998). "The State of the Notion: Knowledge Management in Practice*." California Management Review* 40(3): 80-89.

[41] Ruppel, C. P. and S. J. Harrington (2001). "Sharing Knowledge through Intranets: A Study of Organizational Culture and Intranet Implementation." *IEEE Transactions on Professional Communication* 44(1): 37-50.

[42] Schiemann, W. A. and J. Lingle (1998). "Seven Greatest Myths of Measurement." *IEEE Engineering Management Review* 26(1): 114-116.

[43] Stein, E. W. and V. Zwass (1995). "Actualizing Organizational Memory with Information Systems." *Information Systems Research* 6(2): 85-117.

[44] Stewart, T. (1997). *Intellectual Capital: The New Wealth of Organizations*. New York, Doubleday.

[45] Straub, D. W., D. L. Hoffman, B.W. Weber, and C. Steinfield (2002). "Measuring e-Commerce in Net-Enabled Organizations: An Introduction to the Special Issue." *Information Systems Research* 13(2): 115-124.

[46] Sveiby, K. E. (1997). *The New Organizational Wealth: Managing and Measuring Knowledge-based Assets*. San Francisco, Barrett-Kohler.

[47] Tanriverdi, H. (2002). "Does IT Knowledge Relatedness Differentiate Performance of Multi-business Firms?" *International Conference on Information Systems*, Barcelona.

[48] Tiwana, A. (2000). *The knowledge management toolkit: practical techniques for building a knowledge management system*. Upper Saddle River, N.J., Prentice Hall.

[49] Verkasalo, M. and P. Lappalainen (1998). "A Method of Measuring the Efficiency of the Knowledge Utilization Process." *IEEE Transactions on Engineering Management* 45(4): 414-423.

[50] Wasko, M. M. and S. Faraj (2000). "It is what one does": why people participate and help others in electronic communities of practice." *The Journal of Strategic Information Systems* 9(2-3): 155-173.

[51] Wei, C., P.J. Hu, and H. Chen (2002). "Design and Evaluation of a Knowledge Management System." *IEEE Software*, 19(3): 56-59.

[52] Zack, M. H. (1999). "Managing codified knowledge." *Sloan Management Review* 40(4): 45-58.