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Mapping research trends in the field of knowledge management

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ABSTRACT

This paper aims to map the research trend in the field of knowledge management (KM) by presenting a systematic and analytical scientometrics approach based on data from the Web of Science (WoS). The method for science mapping includes the following steps: Defining the domain; identifying keywords related to KM field and its subfields; conducting searches and collecting the publication and citation data from WoS; drawing the structure of scientific productions using scientometrics tools; enriching the science maps by adding new attributes; and analyzing the results. In this study, we provide a visualization overview of the wide distribution of KM publications. The analysis of clusters of the historiographical maps, based on Local Citation Score (LCS) and Global Citation Score (GCS), indicated the most frequent thematic trends. The co-word occurrence analysis for mapping KM research topics shows that the structure of fundamental subject areas within the field of KM has changed and expanded dynamically during 2004-2010. This study could be useful for researchers and subject specialists as well as policy makers as they may view and study the history of a discipline by drawing the structure of its scientific productions, in order to do strategically plan and determine the research priorities in the discipline.

Keywords: Knowledge management; Research trend; Science mapping; Domain discovery; Information visualization; Scientometrics.

INTRODUCTION

In bibliometrics and scientometrics research, much attention has been paid to the analysis of networks of documents, keywords, authors, or journals. Mapping and clustering techniques are frequently used to study such networks. The techniques are used to address questions such as what are the main topics or the main research fields within a certain scientific domain and how do these topics or fields relate to each other (Waltman, Jan van Eck and Noyons 2010). Science mapping analyses the networks of links between articles (citations, co-authorship), patents, or other information entities to understand the structure of science (Borner, Chen and Bonyak 2003), and can be used as a tool for science strategy and evaluation. A variety of methods have been used in science mapping, such as journal citation analysis, co-citation analysis, bibliometrics coupling, and co-word analysis. In recent years visualization tools have been improved to make the maps more informative and easier to understand (Besselaar and Heimeriks 2006).

Visualization mapping is used to explore large amounts of data and to derive new insights by identifying trends, or clusters, in the data associated with a field of study (Lee and Chen 2012). The map created through citation analysis provides a series of historical data, which cover the literature year by year (Garfield 1955) and (Small 1993). One of the earliest attempts to pictorially represent scientific development was Garfield's historiograph (Garfield 1979). This is a diagram of citation patterns depicting the linking of papers forward and backward in time to trace the lineage of ideas over several generations. In a landmark study (Garfield, Sher and Torpie 1964), a historical account of the discovery of the genetic code was correlated with a citation network. Forty years later, his HistCite™ tool automatically generates chronological tables and historiographs of topical paper collections. It assists researchers and librarians in the following areas: identifying core papers on a topic in question; understanding the impact of specific authors, papers, and journals; and making sense of the history of old and new research topics.

Since then, new methods of information retrieval and new techniques for the analysis, visualization and spatial positioning of information studied based on techniques for visualizing the structure of small scientific domains begin to proliferate (Borner, Chen and Bonyak 2003). Ding et al. (2000) used bibliometrics techniques to break down an area of knowledge into its main elements, and represent the areas and sub-areas graphically. Knowledge domain visualization (KDV) detects and visualizes emerging trends and transient patterns in the scientific literature (Chen and Xie 2005). Some research works in knowledge discovery and data mining systems perform analysis of the engineering domain (Mothe and Dousset 2004; Mothe et al. 2006). Lin, Soergel and Marchionini (1991) developed a self-organizing map (SOM) that represents the semantic relationships among documents and can be used as a bibliographic interface for the retrieval of online information. Braam, Moed and Van Raan (1991a) proposed the combined use of co-citation with co-word analysis for the generation of science maps, emphasizing their structure and dynamic aspects. Borner, Chen and Bonyak (2003) concluded that since domain visualizations are typically based on reference key works in a field, they are a good tool to enable the novice to become familiar with a field through easy identification of landmark articles and books, as well as members of the invisible college or specialties.

Co-word analysis is also an important method of information metrology, proposed as early as the late 70s in 20th century by the French bibliometricians. Currently, mature visualization skills of co-word analysis have been applied in many subjects and disciplines, such as nanotechnology (Kostoff et al. 2006), knowledge management (Ponzi 2003; Hou et al. 2006), the international scientific studies (Hou et al. 2006), human genome (Doisneau-Sixou et al. 2003), bioinformatics (Law and Courtial 1988) and medical informatics (Wagner and Leydesdorff 2005).

This paper presents a new approach for schematic visualization applied to the analysis of scientific domains. The scientific domain chosen is knowledge management (KM), and a total of 50,862 KM research articles published from 2001 to 2010, covered in the Web of Science (WoS) database was analysed.

LITERATURE REVIEW

KM publications in general focus on knowledge in organizations, knowledge-based, theory of the firm, strategy, and knowledge creation. Even though KM discipline is relatively a new research discipline, it has already boasted a number of scientometrics research with the

purpose of better understanding its identity. Ponzi (2002) looked at the breadth and depth of the field, and searched for interdisciplinary connections among researchers. Chauvel and Despres (2002) examined KM research area in six dimensions: phenomena, action, level, knowledge, technology and outcome. Serenko and Bontis (2004) applied meta-analysis to publications in three major KM journals (*Journal of Knowledge Management, Journal of Intellectual Capital* and *Knowledge and Process Management*). Nonaka and Peltokorpi (2006) extended this work by examining the most influential KM publications, and explored the specific issues of subjectivity and objectivity. Dattero (2006) analyzed collaboration preferences of KM scholars, and Harman and Koohang (2005) compared the topics of doctoral dissertations in the KM field with publication frequency and the topics of books. The purpose of Nonaka and Peltokorpi's research (2006) was to review and position 20 of the most frequently cited KM articles in management journals.

Guo and Sheffield (2008) who studied KM theoretical perspectives, research paradigms and research methods revealed that KM research covers the positivist, interpretive and critical pluralist paradigms. Nie, Ma and Nakamori (2009) explored six essential issues regarding KM research field, which include: why the research field is necessary; what enables its birth or triggers actions on it; what it deals with; how to implement it; how to support it; and where it has been applied. Lee and Chen (2007) addressed the topical content in knowledge engineering, semantic web and artificial intelligence related sub-areas. Serenko et al. (2010) conducted citation analysis of individuals, institutions, and countries in KM and intellectual capital fields. The results indicated the publications from several leading authors and foundations are referenced regularly. Dwivedi et al. (2011) found organizational and systems context-based KM research are the most widely published topics. Chen and Lee (2012) built an intellectual structure by examining a total of 10,974 publications in the knowledge management (KM) field from 1995 to 2010. Document co-citation analysis, pathfinder network and strategic diagram techniques were applied to provide a dynamic view of the evolution of knowledge management research trends.

The current study introduces a method to visualize the research trend and derive the intellectual structure of the domain KM based on a combined use of cited references, co-authorship and co-word occurrence. This method is used to provide a visualization representation of the structure map of any scientific field or related subfield obtained from publications appearing in different time periods.

OBJECTIVES

The aim of the present work is to map research trends in the field of KM by presenting a systematic and analytical scientometrics approach based on WoS data. Two research questions are posed:

a) What are the international research trends in the field of knowledge management and each of its sub-domains in the last ten years?
b) What are the most important scientific clusters formed in the historiographical map of knowledge management publications indexed in WoS during 2001-2010? What are their subject areas?

METHOD

This research involved the following six steps for scientific mapping of KM literature:

a) Domain discovery: We defined some keywords representing the domain clearly. We used these keywords to find and retrieve articles relevant to KM.

b) Keyword extracting: We extracted the keywords by scanning materials gathered in step (a) and under expert supervision.

c) Data gathering and preprocessing: We used Web of Science as it is a quality-controlled database of scientific articles and has a unifying research tool which enables the user to acquire, analyze and process the information in a timely manner.

d) Drawing basic science map: Different science maps can be drawn from different viewpoints and for different purposes. In this study we drew maps based on co-authorship, co-word occurrences, and citation historiography. Co-word analyses and co-word occurrences were used. When two professional terms expressing a particular research topic appear in the same article these two words have certain intrinsic relationship. And the more the co-occurrences between these two words, the closer their relationship is. According to this ''distance'', the important keywords of a subject are classified further to sum up the research focus, structure and paradigm of a discipline by modern statistical techniques, such as factor analysis, cluster analysis, multidimensional scaling analysis or multivariate analysis methods. There are other tools which can be used in drawing the structure of science in each field. Among them, HistCite™ has more capability in drawing the map of science and the structure of a field, like its ability to provide detailed information about authors, journals, cited references, keywords, yearly output and other data. Added to these applications, HistCite™ can draw historiographs based on Local Citation Score (LCS) and Global Citation Score (GCS) to show the important works and history of science in a field or in an organization, so we decided to use HistCite™ for this research. Also, we used the co-authorship network to answer a variety of questions about collaboration patterns in KM field, such as the numbers of papers authors write, how many people they co-author with, and the times cited of the co-authored papers.

e) Enriching science map: As some of the maps were unclear or too complex to analyze, we used some pre-processing to simplify the maps. This step, which is one of the main contributions of this study, is enriching the maps. Adding more attributes such as colours, different shapes or varying in size and thickness are among common techniques to enrich the basic maps. Excluding elements based on specific filters also helps neglect unnecessary data and simplify the maps.

f) Analyzing the results: In the last step we will try to find the answers to our research questions by exploring the maps and analyzing the data.

Figure 1 illustrates the six steps involved.

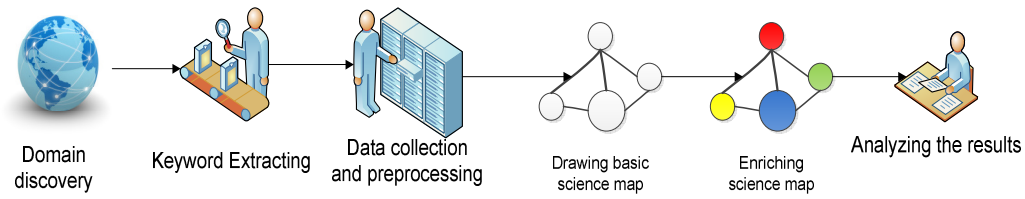

Figure 1: Schematic Presentation of the Methodology

RESULTS

Domain Discovery

KM has existed as a separate field of scientific research for almost a decade. In the midst of finding and studying fundamental papers, books and other related reference works on KM, as well as obtaining experts' opinions to partition KM to smaller sub-categories, we found a useful documents i.e. a knowledge management encyclopedia, which proposes a comprehensive classification of this domain. This encyclopedia classifies KM into six logical categories. We used five of these six categories as a basis for explaining our domain and extended it in the next step. According to our extracted domain, we can look at the KM from theoretical, procedural, managerial, technological and organizational viewpoints. Therefore we tried to find keywords which represent these categories clearly in the next step.

Keyword Extraction

Figure 2 depicts the final categories and the associated keywords for drawing science maps. Firstly, these keywords were extracted from papers related to each category, experts' opinions and the knowledge management encyclopedia. Then the glossary with hundreds of terms was processed to find similar phrases and was reduced by cutting very specific words. The final list was given to the experts and we received their feedback about the glossary in a couple of rounds.

Data Gathering and Pre-processing

We need to identify an appropriate database for searching and retrieving documents to draw science maps based on these criteria: comprehensiveness of materials, metadata standards, supportive software for analyzing and mapping, and ease of use. After investigating different data sources and scientific collections and applying the mentioned criteria, we decided to extract data from WoS. We searched WoS database in March 2010 using the extracted keywords in Figure 2.

The final dataset consists of a total of 50,862 documents indexed in WOS during 2001-2010 (Figure 3). As can be seen, the lowest number of records is in 2001 and the most records is in 2009. The documents in 2010 have not been completely covered by WoS during that time. The yearly growth rate for these publications in WOS was 10.9% per year. As we needed to process extracted data wholly, the search results should be integrated in one database. A total of 65,696 author keywords were found in the retrieved articles. Table 1 presents the top 20 keywords based on publication year of articles. This confirms the importance of these words in KM field.

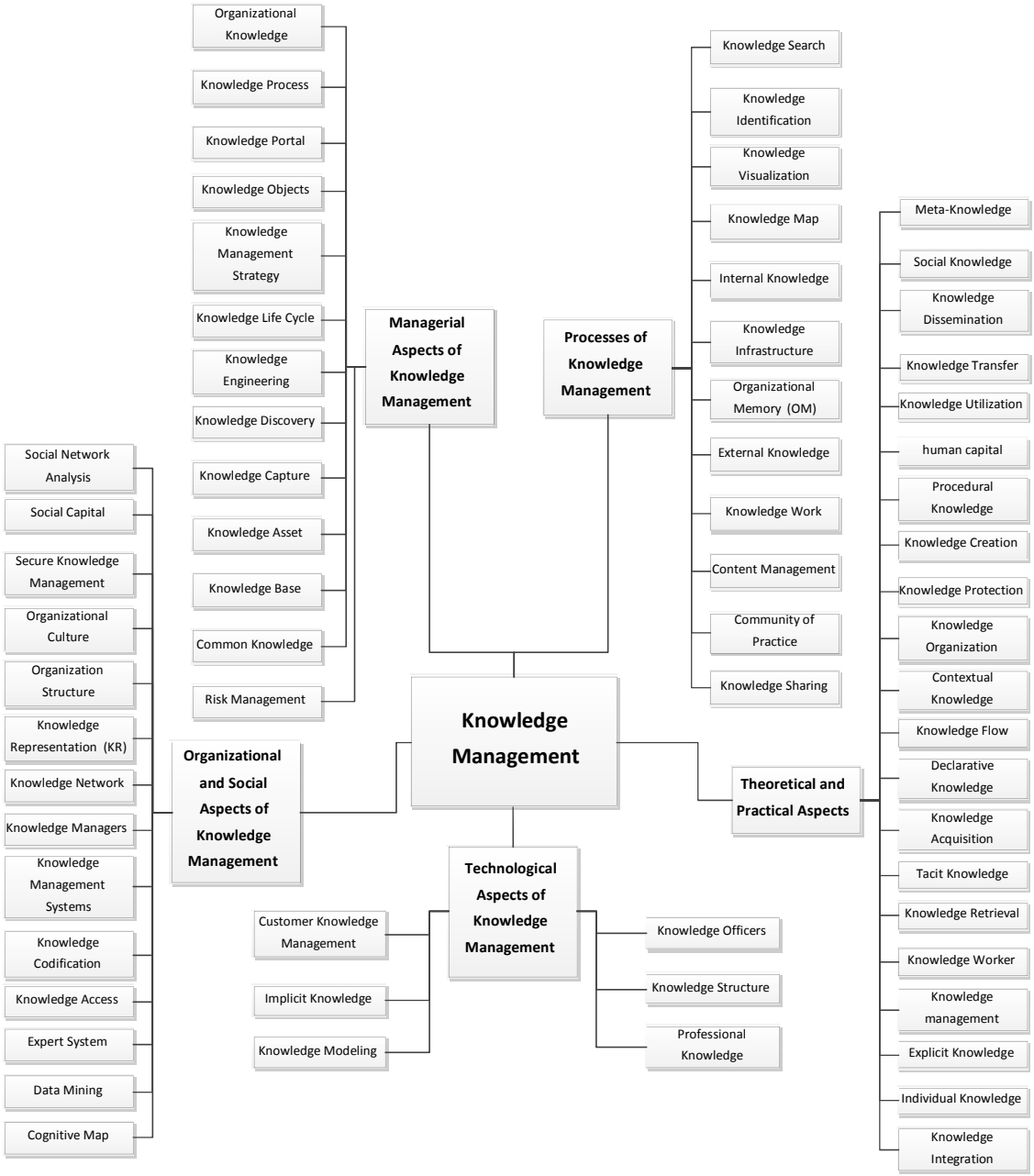

Figure 2: Major and Minor Categories Related to Knowledge Management

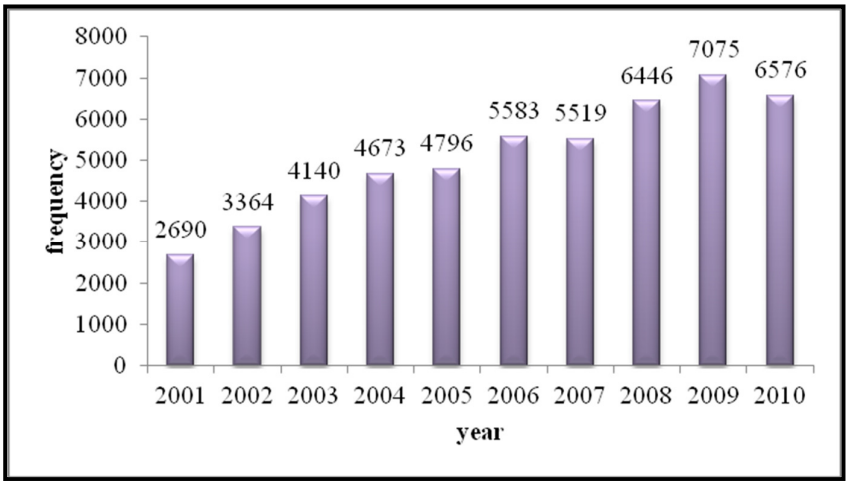

Figure 3: The Number of Knowledge Management Documents Indexed in WOS (2001-2010)

Table 1: Top 20 Keywords based on the Publication Year of Articles

Year / Keywords	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Data mining	158	189	268	291	271	359	409	443	546	441	3375
Risk management	87	110	140	142	154	207	212	215	118	323	1708
Knowledge management	83	102	130	127	158	156	177	200	299	243	1675
Social capital	56	67	100	97	136	151	193	232	263	241	1536
Human capital	52	58	80	93	74	105	114	160	162	168	1066
Knowledge representation	38	44	56	73	59	68	44	61	57	49	549
Organizational culture	13	18	47	32	37	56	70	79	92	98	542
Expert system	22	41	64	47	47	54	68	74	63	57	537
Organizational learning	38	38	42	37	36	50	38	45	63	58	445
Classification	12	32	35	39	41	60	45	52	69	59	444
Knowledge discovery	38	36	36	40	45	41	45	52	44	30	407
Innovation	13	20	18	28	21	36	43	57	76	78	390
Risk assessment	23	29	44	43	34	48	36	50	15	59	381
Clustering	8	22	30	37	51	35	51	58	44	44	380
Machine learning	27	25	41	38	41	51	34	42	36	45	380
Knowledge	22	23	30	33	23	37	42	53	52	40	355
Knowledge sharing	7	9	13	18	25	26	38	70	78	71	355
Knowledge acquisition	31	33	34	27	18	43	38	41	39	36	340
Ontology	9	9	24	24	25	34	39	50	62	55	331
Education	16	18	21	19	26	30	36	50	60	47	323

Drawing and Enriching Historiographical Map

HistCite™ has been used in the drawing of historiographs based on Local Citation Score (LCS) and Global Citation Score (GCS). The 50,862 retrieved documents on KM received a total of 59,153 local citations and 338,377 global citations. We drew the LCS map with only 150 nodes, due to the high number of links, and the need to have a clearly presented graph. Figure 4 shows the main clusters of this structure. There are four clusters and each cluster consists of a number of documents.

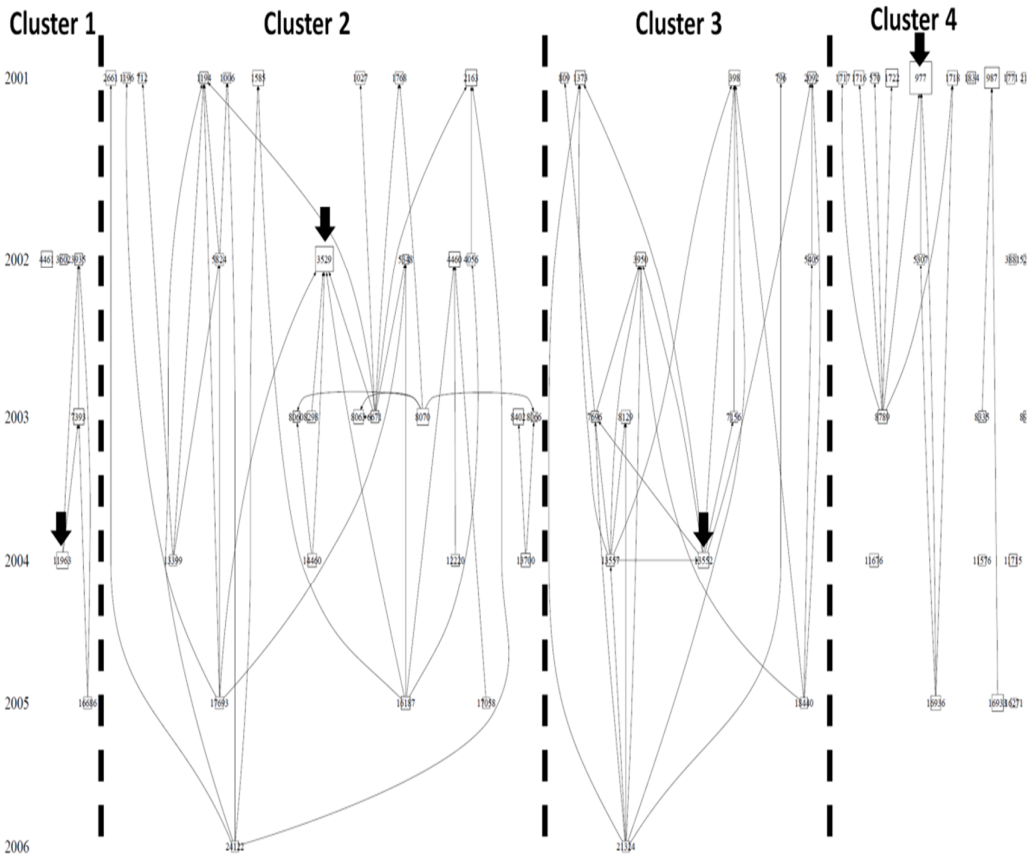

Figure 4: Historiograph of Documents in Knowledge Management Field based on Local Citation Score (LCS) with 150 Top Nodes

The first cluster, which is the largest cluster in this structure, consists of 52 documents during 2001-2006. In this cluster, document number 3529 received the most local citations (289) in comparison with the other documents, followed by document number 987 (187 LCS), 2163 (123 LCS) and 4460 (93 LCS) respectively. The subject area of the first cluster is "the organizational and social aspects of knowledge management". A small second cluster with 5 documents established during 2002-2005 can be seen and document number 11963 under the subject "process of knowledge management" received the most local citations (114). This cluster is associated with several other documents on "tacit knowledge" and "spatial clustering". The third cluster with 22 documents was established during 2001-2006 and is related to the first cluster. The document that received the highest LCS (101) is document number 13,552, which has established many links to other documents in this cluster. The forth cluster with 19 documents was established during 2001-2005. In this cluster, document

number 977 received the most local citations (417 LCS) in comparison with other studied documents. This article, published in *MIS Quarterly* belonged to the "conceptual foundations of knowledge management" and is one of the most effective article in this field and in this time range. The other important documents in this cluster, all published in the *Journal of Management Information Systems* are included: 1722, 1716, and 8789. Table 2 presents the bibliographic data of the documents in the mains clusters with their respective LCS and GCS.

Table 2: Bibliographic Data of the Documents in the Main Clusters

Document number	Bibliographic data	LCS	GCS
3529	Adler PS, Kwon SW .Social capital: Prospects for a new concept. *Academy of Management Review*. 2002 Jan; 27 (1): 17-40	289	594
987	Brown JS, Duguid P. Knowledge and organization: A social-practice perspective, *Organization Science*. 2001 Mar-Apr; 12 (2): 198-213	187	374
2163	Tsai WP. Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance, *Academy of Management Journal*. 2001 Oct; 44 (5): 996-1004.	123	Unknown
4460	Hansen MT. Knowledge networks: Explaining effective knowledge sharing in multiunit companies *Organization Science*. 2002 May-Jun; 13 (3): 232-248.	93	190
11963	Bathelt H, Malmberg A, Maskell P. Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation *Progress in Human Geography*. 2004 Feb; 28 (1): 31-56.	114	311
13552	Szreter S, Woolcock M. Health by association? Social capital, social theory, and the political economy of public health. *International Journal of Epidemiology*. 2004 Aug; 33 (4): 650-667	101	142
977	Alavi M, Leidner DE. Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly.* 2001 Mar; 25 (1): 107-136	417	778
1722	Gold AH, Malhotra A, Segars AH. Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems*. 2001 Sum; 18 (1): 185-214	127	261
1716	Grover V, Davenport TH. General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems*. 2001 Sum; 18 (1): 5-21	83	162
8789	Lee H, Choi B. Knowledge management enablers, processes, and organizational performance: An integrative view and empirical examination. *Journal of Management Information Systems*. 2003 Sum; 20 (1): 179-228	69	131

Therefore, in a general classification based on LCS, the fours clusters can be classified by the following subjects respectively: (a) organizational and social aspects of knowledge management; (b) tacit knowledge and spatial clustering; (c) role of social capital in knowledge management; and (d) conceptual foundations of knowledge management.

In the GCS map, the classification of the four clusters by subject are as follows: (a) role of social capital in knowledge management; (b) social-practice perspective of knowledge; (c) conceptual foundations of knowledge management; and (d) tacit knowledge and spatial clustering.

Co-authorship Network

A co-authorship network is used to answer a broad variety of questions about collaboration patterns, such as the numbers of papers authors write, how many people they co-author with, the typical distance between authors through the network, and how collaboration patterns vary between authors and over time. We used network workbench (NWB) software to draw the co-authorship network of KM publications. In this network, the nodes represent authors and the size of the nodes indicates the number of articles each author has written. The lines or edges indicate the co-authorship and the line thickness represents the frequency of co-authorship. Figure 5 depicts the KM co-authorship network, composed of 200 top nodes and 128 edges. There are 125 weakly connected components. This network has two large nuclei and other nuclei contain smaller groups (usually 3 or 4 people). In this network, authors who have the most collaboration with others are highlighted: Chen, YM., Wang, CB., Cheu, HC., Lee, WB., Chen, YJ. and Gottschalk, P. These authors also have the highest number of articles in this network. As can be seen, most of them are also the most cited authors.

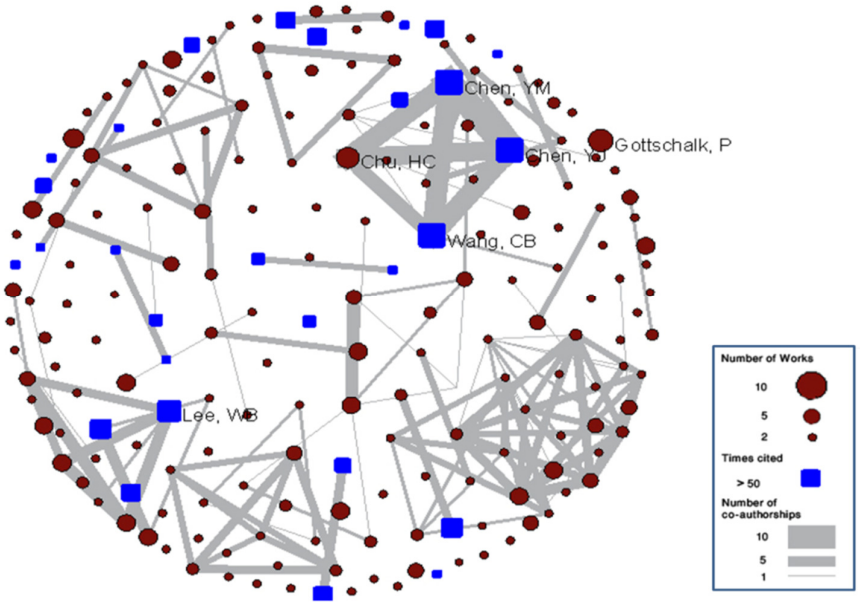

Figure 5: Co-authorship Network of Knowledge Management Field

Co-word Occurrence Maps

Co-word analysis enables the structuring of data as networks of links and nodes, and as distributions of interacting networks (Yang, Wu and Cui 2012). In this study, we applied co-word occurrence analysis for mapping KM research topics. Due to the complexity of co-occurrence word network extraction process, we focused on records that were retrieved using the keyword search “knowledge management”. The extracted data were analysed based on 4 time periods: 2004-2005, 2006-2007, 2008-2009 and 2010. The co-occurrence word networks were extracted on records original keywords and by the aid of Sci2 tools package. The outputs graphs were exported as GraphML XML files. The final representations were drawn using NodeXL package which is an add-in for Microsoft Excel. Figure 6 exhibits four snapshots of the mentioned networks filtered by important KM topics.

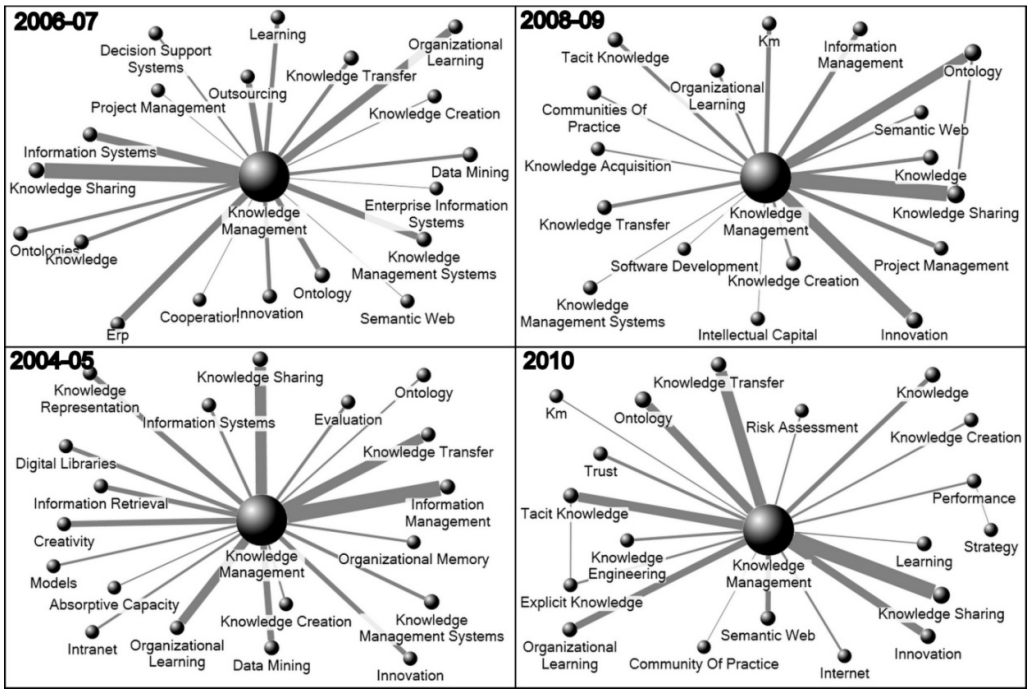

Figure 6: Co-occurrence Word Maps of Knowledge Management during 2004-2010

The size of the spheres depicts frequency of each keyword; edge depicts the connection relationship between two words; and the thickness of the lines indicates the strength of connection. The strongly related words are linked with the thick line and the weakly related words are linked with the thin line, that is, the thicker the line between the two nodes, the closer the relationship is.

From exploring the networks and comparing them with each other, we can see the stability and change in KM research topics. A number of topics are present in all years, whereas some topics have disappeared. New topics emerge as a recombination of existing topics and in interaction with technological developments. For instance, looking at the phrases such as “ontology” chronologically demonstrates the evolution of this concept and its relation with KM. In 2010 map some new topics emerged such as “trust”, “risk assessment”, “knowledge engineering” and “performance”. It is interesting that “strategy” is connected to “KM” via “Performance”. The relation between keywords such as “digital libraries” and “information retrieval” with KM concealed as time went by.

DISCUSSIONS AND CONCLUSIONS

Understanding and evaluating research is essential for research planners, policy makers and researchers. One of the most efficient methods in evidence-based research assessment is the use of scientometrics approach in examining scientific output covered by global citation databases. Considering the distinct status of knowledge management in modern organizations and its effective role in improving the efficiency and effectiveness of organizational processes, drawing a picture of the scientific publications structure produced by researchers in this area is necessary.

In this study, we have provided a visual overview of the wide distribution of KM publications by analyzing KM articles published during 2001–2010 periods covered by WoS. The yearly growth rate for KM publications in WoS was about 10.9%. We introduced a method based on a combined use of cited references, co-authorship and co-word occurrence to visualize the research trend in KM. The method can be applied to any science field to help understand research trends and their evolution. The resulted maps are mostly network representation of elements such as authors, subjects or papers. The resulted co-word occurrence maps give an insightful representation of the research topics within KM field. Based on the analysis of clusters of the historiographical maps, some of the major subject areas in KM field are organizational and social aspects of knowledge management such as “social capital”, “knowledge network”, and “analysis of social network”. A big cluster is allocated to these subjects in both maps based on LCS and GCS. The subject areas of the other clusters are such as “tacit knowledge and spatial clustering”, “conceptual foundations of knowledge management” and “the impact of social capital on knowledge management”. We also applied co-word occurrence analysis for mapping KM research topics, and the analysis shows that the structure of fundamental subject areas within the field of KM has changed and expanded dynamically during 2004-2010.

Using information visualization in different scientific disciplines could be useful for researchers and subject specialists as well as policy makers. The researchers and subject specialists at a glance can see which topics in their discipline have been under research by their peers, and which areas have been less attended to during a specific time period. The results of such studies would assist the policy makers in the allocation of research funding to specific topics and subject fields with more confidence (Osareh and Keshvari 2010).

We acknowledge that this study has a number of limitations. For instance, due to the huge number of extracted records, we could not do any data cleaning (such as removing spelling errors in keywords) or pre-processing (such as word stemming). Doing so would definitely improve the accuracy of information presented in the historiographical map of KM publications.

Another limitation is in using the co-citation method, for newly published papers may not have enough time to garner citations. However, we believe this study could be useful for a wide range of users, notably scientists, researchers and librarians. It can also help early career researchers gain useful and interesting insights into the exciting field of KM. Future studies in this area could be done using other analytical approach and the results be compared with each other.

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REFERENCES

Besselaar, Peter Van Den, and Heimeriks Gaston. 2006. Mapping research topics using word-reference co-occurrences: A method and an exploratory case study. *Scientometric*, Vol. 68, no. 3: 377–393.

Börner, K., Chen, C. and Boyack, K. W. 2003. Visualizing knowledge domains. *Annual Review of Information Science and Technology*, Vol. 37, no. 1: 179–255.

Braam, R. R., Moed, H. F. and Van Raan, A. F. J. 1991a.Mapping of Science by combined co-citation and word analysis. I: Structural aspects, *Journal of the American Society for Information Science (JASIS).* Vol. 42, no. 4: 233–251.

Braam, R. R., Moed, H. F. and Van Raan, A. F. J. 1991b. Mapping of Science by combined co-citation and word analysis. II: Dynamic aspects, *Journal of the American Society for Information Science (JASIS),* Vol. 42, no. 4: 252–266.

Chauvel, D. and Despres, C. 2002.A review of survey research in knowledge management: 1997–2001. *Journal of Knowledge Management*, Vol. 6, no. 3: 207–223.

Chen, T.T. and Xie, L. 2005.Identifying critical focuses in research domains, In *Proceedings of 9th International Conference on the Information Visualization* (IV'05), London UK, 6-8 July 2005135–142.

Cronin, B. and Atkins, H. B. E. 2000. *The Web of Knowledge: A festschrift in honor of Eugene Garfield*. ASIST.

Dattero, R. 2006. Collaboration between the top knowledge management/intellectual capital researchers. *Knowledge and Process Management*, Vol. 13, no. 4: 264-269.

Ding, Y., Chowdhury, G. G., Foo, S. and Qian, W. 2000. Bibliometric information retrieval systems (BIRS): a web search interface utilizing bibliometric research results, *Journal of the American Society for Information Science (JASIS).*Vol. 51, no. 13: 1190–1204.

Doisneau-Sixou, S.F., Sergio, C.M., Carroll, J.S., Hui, R., Musgrove, E.A. and Sutherland, R,L. 2003. Estrogen and antiestrogen regulation of cell cycle progression in breast cancer cells. *Endocrine-related cancer,* Vol. 10, No.2: 179-186.

Dwivedi, Y., Venkitachalam, K., Sharif, A., Al-Karaghouli, W. and Weerakkody, V. 2011. Research trends in knowledge management: analyzing the past and predicting the future. *Information Systems Management,* Vol. 28, no. 1: 43–56.

Epler, Martin J. and Burkhard, Remo A., 2007. Visual representations in knowledge management: framework and cases, *Journal of Knowledge Management*, Vol.11, no. 4: 112-122.

Garfield, E. 1955. Citation indexes for science. *Science*, Vol. 122, no. 3159: 108-111.

Garfield, E. 1979. *Citation indexing—its theory and application in science, technology, and humanities*. New York: John Wiley.

Garfield, E. 1994. Scientography: Mapping the track of science. *Current Contents: Social & Behavioural Sciences*, Vol. 7, no. 45: 5-1.

Garfield, E., Sher, I.H. and Torpie, R.J. 1964. *The use of citation data in writing the history of science*. Philadelphia: Institute for Scientific Information.

Gu, Y. 2004. Global knowledge management research: a bibliometric analysis. *Scientometrics,* Vol. 61, no. 2: 171-190.

Guo, R. and Sheffield, J. 2008. Paradigmatic and methodological examination of knowledge management research: 2000–2004. *Decision Support Systems*, Vol. 44, no. 3: 673–688.

Harman, K. and Koohang, A. 2005. Frequency of publication and topical emphasis of knowledge management books versus doctoral dissertations: 1983-2005. *Journal of Computer Information Systems*, Vol. 46, no. 2: 64-68.

Hou, H.Y., Liu, Z.Y., Chen, Y., Jiang, C.L., Yin, L.C., and Pang, J. 2006. Mapping of science studies: the trend of research fronts [J]. *Science Research Management, 03*. Dalian,

China: WISE LAB, Institute of Science Studies and Management of Science and Technology, Dalian Universtiy of Technology.

Kostoff, R.N., Stump, J.A., Johnson, D., Murday, J.S., Lau, C.G.Y., and Tolles, W.M. 2006. The structure and infrastructure of the global nanotechnology literature. *Journal of Nanoparticle Research,* Vol. 8, no. 3-4:301-321.

Law J. and Courtial, J.P. 1988. A co-word study of artificial intelligence. *Social Studies of Science* , Vol. 19, no.2. 301–311.

Lee, Maria R. and Chen, Tsung Teng. 2012. Revealing research themes and trends in knowledge management: From 1995 to 2010. *Knowledge-Based Systems,* Vol. 28: 47–58.

Lin, X., Soergel, D. and Marchionini, G. 1991. A self-organizing semantic map for information retrieval, In: *Proceedings of the Fourteenth Annual International ACM/SIGIR Conference on Research and Development in Information Retrieval*, Chicago, 13-16 Oct 1991, 262–269.

Morris, S. A., Van der Veer Martens, B. 2008. Mapping research specialties. *Annual Review of Information Science and Technology*. Vol. 42, no. 1: 213–295.

Mothe, J. and Dousset, B. 2004. Mining document contents in order to analyze a scientific domain, In: *Sixth International Conference on Social Science Methodology,* Amesterdam, The Netherlands, 16-20 August, 2004, Leverkusen-Opladen: Verlag Barbara Budrich /Rammington Hills: Barbara Budrich Publishers.

Mothe, J., Chrisment, C., Dkaki, T., Dousset. B. and Karouach. S. 2006. Combining mining and visualization tools to discover the geographic structure of a domain Computers, Environment and Urban Systems, Vol. 30, no. 4, 460–48.

Nie, K., Ma, T. and Nakamori, Y. 2009. An approach to aid understanding emerging research fields – the case of knowledge management Systems. *Research and Behavioral Science*, Vol. 26, no. 6: 629–643.

Nonaka, I. and Peltokorpi, V. 2006.Objectivity and subjectivity in knowledge management: a review of 20 top articles, *Knowledge and Process Management*, Vol. 13, no. 2: 73-82.

Osareh, F. and Keshvari, M.2010.*Visualizing the Structure of Scientific Output of Iranian Scholars in Science Citation Index (SCI) during 2000-2006.* IMCW 2010, CCIS Vol. 96: 200–210.

Ponzi, L.J. 2002.The intellectual structure and interdisciplinary breadth of knowledge management: a bibliometric study of its early stage of development, *Scientometrics*, Vol. 55, no. 2: 259-272.

Ponzi, L.J. 2003. *The evolution & intellectual development of knowledge management*. Ph.D. Dissertation, Long Island University.

Schwartz*,* David G. 2006. *Encyclopedia of Knowledge Management*, Idea Group Reference.

Serenko, A. and Bontis, N. 2004. Meta-review of knowledge management and intellectual capital literature: citation impact and research productivity rankings *Knowledge and Process Management,* Vol. 11, no. 3: 185-198.

Serenko, A. and Bontis, N. 2009. Global ranking of knowledge management and intellectual capital academic journals. *Journal of Knowledge Management*, Vol. 13, no. 1: 4-15.

Serenko, A., Bontis, N., Booker, L., Sadeddi, K. and Hardie, T. 2010. A scientometric analysis of knowledge management and intellectual capital academic literature (1994-2008). *Journal of Knowledge Management*, Vol. 14, no. 1: 3-23.

Small, H. 1998. Visualizing science by citation mapping. *Journal of the American Society for Information Science*, Vol. 50, no. 9: 799-813.

Wagner, C. and Leydesdorff, L. 2005. Mapping Global Science using International Co-authorships: A Comparison of 1990 and 2000. *International Journal of Technology and Globalization,* Vol. 1, no. 2. 185-208.

Waltman, , L., Jan van Eck, N. and Noyons, Ed C.M. 2010. *A unified approach to mapping and clustering of bibliometric networks*. Leiden, the Netherlands: Centre for Science and Technology Studies, Leiden University.

Yang, Y., Wu, M. and Cui, L. 2012. Integration of three visualization methods based on co-word analysis. *Scientometrics,* Vol. 90, no. 2: 659–67.