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Mapping the Intellectual Structure of Knowledge Management Subject Area: A Co-citation Network Analysis

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Abstract

The aim of the research is mapping the intellectual structure of knowledge management subject area to explore more its past and present. This Scientometric research has been done by author co-citation analysis of KM during time span of 1990-2014. We also used new social network indicators to understand the field better. The findings showed that different specialties can be recognized in the KM field. Half of the specialties are interrelated which shows the interdisciplinary nature of the KM fields. The results also showed that the impact of works written by Davenport, Polanyi and Brown with 928, 650 and 513 citation is more than other core authors of the field, and the stability of Drucker, Schon, Nelson, and Polanyi Theories with 36, 29, 26 and 25 citation half-life is more than other theories.

Keywords: Knowledge Management, Knowledge Domain Visualization, Co-citation.

Introduction

Knowledge management is an evolving subject area which has affected different domains such as management, Information science, industrial engineering and other related domains. This field of science is the process of creating value from an organization‘s intangible assets. Intangible assets, also referred to as intellectual capital, include human capital, structural capital, and customer or relationship capital. This subject area in the last 4 decades has developed and divided into different sub-domains which we name them specialties. Nevertheless there are fewer consensuses about its definition, origin, nature, and pioneers.

Some experts have asserted that knowledge management discourse is affected by different paradigms based on different point of views toward knowledge and its management. However there is no evidence to this asserts. Thus the aim of the research is investigating the dominant paradigms of knowledge management theories and theorists.

We use author co-citation analysis alongside social network analysis techniques to investigate the mentioned premise.

Methodologies

In Author Co-citation Analysis (ACA), cited and co-cited authors are the unit of analysis. As White and Griffith point out, "Co-citation of authors results when someone cites any work by any author along with any work by any other author in a new document of his own"(p. 163). Spatial maps are produced using one of a number of statistical techniques (e.g., cluster analysis, multi-dimensional scaling, and factor analysis). Heavily co-cited authors appear grouped in space, with authors having many links occupying central locations on the maps and authors with weaker links (fewer co-citations) are appeared on the periphery of maps. Thus the mentioned method is the most powerful in representing school of thoughts and shared concepts, methodologies, approaches, and frameworks in a domain.

The population of the research is references of papers in topic of knowledge management published in ISI ranked journals and indexed in WOS during time span of 1990-2014. To understand the concept better, the time span is divided to 5 five-year-slices. The time slices are 1990-1994, 1995-1999, 2000-2004, 2005-2009, and 2010-2014. By these divisions we can better understand the origin, nature and pioneers of KM and its dominant paradigms in these periods of time. The search is done on 25th March 2014.

The source of data was WOS database. We searched "knowledge management" query in topic field and filter the results to time span of 1990-2013. Finally 5826 records were retrieved. The references of papers downloaded as Citespace software (provided by Chaomei Chen) Input format. Then we applied author co-citation analysis technique as one of powerful techniques for representation intellectual structure of a domain.

We prune the data with pathfinder network algorithms.

We selected 30 top more cited authors (as representatives of dominant paradigms and specialties) in specific time spans to compare them based on their network position and social network analysis indicators.

We also analyzed top more cited authors as representatives of dominant paradigms based on social network analysis techniques and methodologies.

After mapping the map of the domain in independent sliced and merged mode we tried to compare the networks in addition of their theoreticians and specialties based on new structural, temporal and citation indicators.

It is expected that the comparison of the networks, specialties and theoreticians (core authors) based on mentioned indicators can be useful in evaluating their paradigm shift, interdisciplinarity, dynamics, cohesion, consensus, impact, diversity in the 5 mentioned slice of time.

Structural indicators used in the research are Betweenness Centrality, Modularity and Silhouette.

Betweenness Centrality measures the percentage of the number of shortest paths in a network to which a given node belongs. Nodes with high-Betweenness Centrality tend to be found in paths connecting different clusters (Chen, 2006). Accordingly a base author with high Betweenness Centrality score is a turning point in a domain.

The modularity Q measures the extent to which a network can be divided into independent blocks, i.e. modules (Newman, 2006; Shibata, Kajikawa & Matsushima, 2007). The modularity score ranges from 0 to 1. A low modularity suggests a network that cannot be reduced to clusters with clear boundaries, whereas a high modularity may imply a well-structured network (Chen and Ibekwe-SanJuan, 2010).

The silhouette metric (Rousseeuw, 1987) is useful in estimating the uncertainty involved in identifying the nature of a cluster. The silhouette value of a cluster, ranging from -1 to 1, indicates the uncertainty that one needs to take into account when interpreting the nature of the cluster. The value of 1 represents a perfect separation from other clusters.

Temporal indicators are citation Burstness and sigma. Burst detection determines whether a given frequency function has statistically significant fluctuations during a short time interval within the overall time period. It is valuable for citation analysts to detect whether and when the citation count of a particular reference has surged.

Sigma (∑) is introduced in (Chen, Chen, Horowitz, Hou, Liu, & Pellegrino, 2009) as a measure of scientific novelty. It identifies scientific publications that are likely to represent novel ideas according to two criteria of transformative discovery. As demonstrated in case studies (Chen et al., 2009), Nobel Prize and other award winning research tends to have highest values of this measure.

Social network analysis (such as page-rank) and other indicators such as density, cited-half-life, and average citation received are other indicators used in the research.

Page-rank algorithm is one of powerful algorithms which indicate the prestige and influence of a base author in a domain. On the other hand the authors or theoretician with high page-rank score are authors with high consensus in a domain.

The density is an indicator which shows the topology of a network. If the topology of a network be similar to small world networks, the network is mature one.

Other indicators such as citation and cited-half-life show the impact and stability of his/her theories.

The author believes that such comprehensive view based on mentioned indicators and methodologies toward knowledge management can be lightening the dark faces of the domain and show dominant paradigms and show how, when and by whom, paradigms are shifted.

Findings

The finding showed that we can cluster knowledge Management in 12 related or unrelated specialty.

Table 1

Clustering the Knowledge management subject area into 13 clusters (Specialties)

	Cluster Label	Base authors	Mean Year	Silhouette
1	Causal ambiguity; firm; technology; innovation	Fornell C Podsakoff PM	1992	1
2	organizational learning.; knowledge workers; information resource management; work; organizational memory	Wiig KM Stein EW	1995	1
3	dialog; organizations; perspective; collaboration; environment	Brown JS Wenger E Lave J	1992	1
4	management-systems; information-technology; media; capability; dynamic capabilities	Hansen MT Davenport T H Zack MH Liebowitz J	1994	.17

	Cluster Label	Base authors	Mean Year	Silhouette
		[Anonymous] Drucker PF Nahapiet J Von Krogh G Odell C Stewart TA Gold AH Mcdermott R Orlikowski WJ Tsoukas H Gupta AK Ruggles R Leonard-barton D Malhotra Y Prusak L Wasko MM Leonard D Bontis N Sanchez R Hammer M Steels L Rouse WB Date CJ Carayannis E Mattos NM Doyle J Maule R Puppe F Brodie ML Harder T Childs DL		
5	databases; decision;	Agrawal R Toroslu IH	1991	1
6	Information product development; knowledge management system; publishing industry; knowledge integration; decision-support; technology; innovation; retrieval; contextualized access to knowledge; knowledge-based systems; interface design; expert systems; explanations; framework; agents; memory; rule;	Conklin J Biennier F	1988	1
7	ontology; database management, logical design; heterogeneous databases; distributed artificial intelligence; object-oriented programming; rdf; artificial intelligence; human learning; organizational learning; mind; holistic/heuristic model; classification framework; thought-pattern; self-organizing system; networks;	Chen Q Banerjee J Salvini S	1988	1

	Cluster Label	Base authors	Mean Year	Silhouette
8	Architecture; firms; strategic performance; organizational knowledge; technological learning	Kogut B Szulanski G Argote L Huber GP Weick KE Hamel G	1992	0.92
9	organizational knowledge; strategic performance; technological learning; multitechnology corporations; research-and-development	Grant RM Teece DJ Cohen WM Spender JC Eisenhardt KM Barney J Zahra SA Mintzberg H Dodgson M	1993	.953
10	Process improvement; software development; supply chain management; information exchange; exchange	Senge PM Argyris C Quinn JB Drucker P	1993	.955
11	Architecture; taxonomy; model management; value chain; trading	Holsapple CW Simon HA Sprague RH Applegate LM Bonczek RH Blanning RW Binbiasioglu M	1977	.86
12	organizational learning.; knowledge workers; information resource management; it tools; human resource management	Nonaka I Alavi M Davenport TH Davenport T Polanyi M Nelson RR Hedlund G	1989	.81
13	design; network; software, web-based applications	Gaines BR Clancey WJ Boehm BW Skuce D Boose J Artificial Intelligence Laboratory of the University of Ottawa	1986	.84

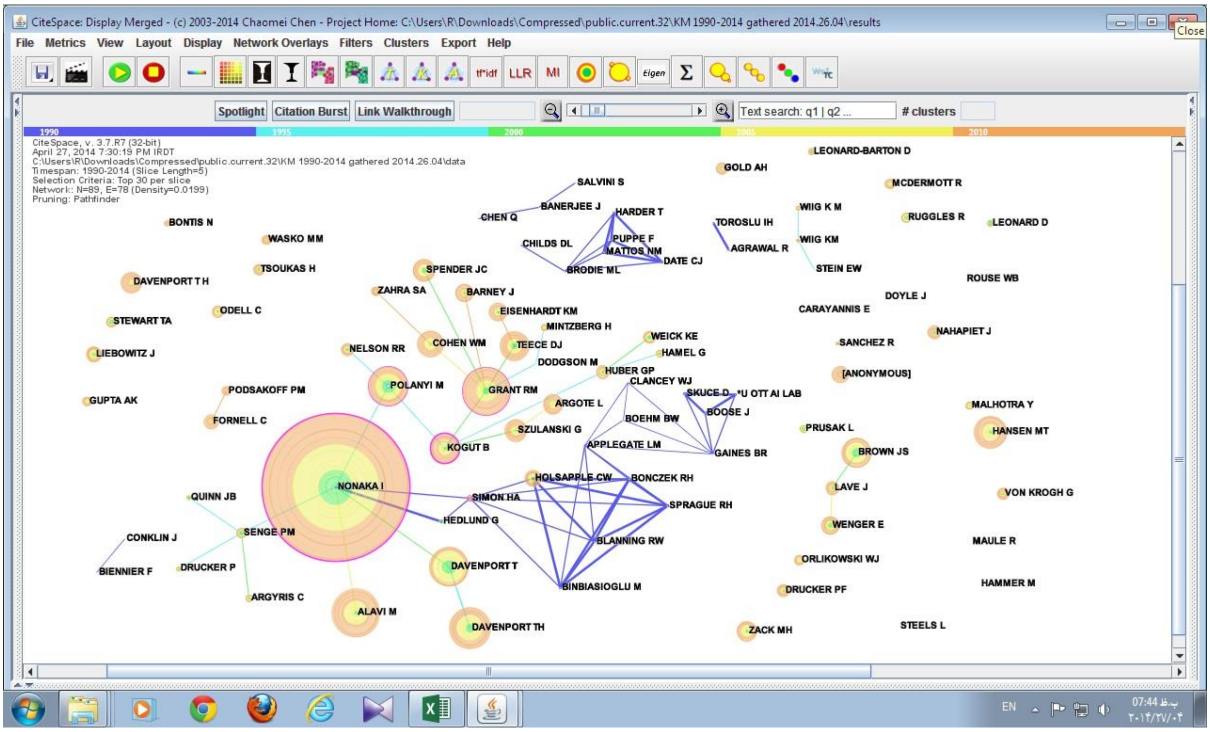

Figure 1. The author co-citation network of KM field

The table 1 and figure 1 show that Knowledge Management subject area can be divided to 13 clusters which 6 clusters (half of them) are independent from the network cores. The most pivotal cluster is 8th. In this cluster the role of Kogut is not neglectable. Thus he is one of pivotal authors of KM subject area. The older cluster is 11th one and the roles of Simon and Applgate as pioneers of KM are prominent. The newest cluster is second and is about organizational memory. The works of Wiig is well known in this cluster. The most important cluster is 12th and the role of top KM authors such as Nanoka, Davenport and Polanyi is prominent. The 10th cluster is a Management oriented KM and is dominated by works of Senge, Argris, Quinn and Drucker works. While it seems that 7th cluster be more technology oriented specialty of knowledge management. The prominent base authors of the specialty are Chen, Banerjee, and Salvini.

Based on Figure 1 the density of the KM network is about 0.02, its modularity is 0.78, and its silhouette is about 0.88. Thus the density indicator shows that the topology of the network is not similar to small world networks and seems to be immature; the modularity indicator shows that the network cannot be divided into independent clusters and half of them are related to altogether; and the silhouette shows that less uncertainty involved in identifying the nature of the network.

Table 2

The Bursted core authors of the KM field

#Key	Times cited	Burst	Publication Year	Burst Begin	Burst End	Span	HalfLife
OLEARY DE	141	7.62	1998	1990	2005	16	8
HEDLUND G	145	9.06	1994	1994	2004	11	12
QUINN JB	152	19.42	1996	1996	2004	9	9
DRUCKER P	164	10.45	1992	1996	2004	9	14
DAVENPORT T	611	39.59	1998	1998	2005	8	8
SVEIBY K E	142	4.66	2001	1997	2004	8	7
SCHON D A	133	8.97	1978	1998	2004	7	29
PRUSAK L	175	13.75	2001	1999	2005	7	5
PRAHALAD CK	177	3.35	1990	1994	2000	7	19
LEONARD-BARTON D	181	15.93	1995	1998	2004	7	11
NELSON RR	259	3.84	1982	1994	2000	7	26
ARGYRIS C	195	6.63	1996	1997	2003	7	11
RUGGLES R	183	12.84	1998	1999	2004	6	8
HUBER GP	280	3.85	1991	1993	1998	6	17
STEWART TA	226	20.57	1997	1997	2002	6	9
MINTZBERG H	187	3.72	1990	1996	2001	6	18
WIIG K M	158	5.38	1994	1996	2000	5	15
SENGE PM	224	13.34	2006	1996	2000	5	1
HAMEL G	177	8.03	1991	1996	2000	5	16
DAVENPORT T H	317	26.42	1998	2010	2014	5	13
DRUCKER PF	295	3.75	1973	1996	2000	5	36
SANCHEZ R	145	5.09	1996	1999	2002	4	13
PODSAKOFF PM	204	10.59	2003	2011	2014	4	8
WIIG KM	186	5.51	2004	1997	2000	4	4
FORNELL C	234	9.53	1987	2011	2014	4	24
BROWN JS	513	10.08	1991	2001	2003	3	16
BOCK GW	156	11.60	2005	2012	2014	3	6
BLACKLER F	167	4.52	1995	2001	2003	3	12
LEONARD D	155	10.35	1998	2000	2002	3	8
MALHOTRA Y	213	4.36	2005	2004	2006	3	2
LEE H	140	8.31	2003	2011	2012	2	8
EDVINSSON L	171	5.21	1997	1999	2000	2	12
TSAI WP	173	4.35	2001	2010	2011	2	10
POLANYI M	650	7.67	1983	2002	2003	2	25
GROVER V	127	4.52	2001	2005	2005	1	7
LAVE J	291	3.29	1998	2002	2002	1	11
HAIR J	127	3.46	1998	2011	2011	1	13
ZAHRA SA	197	5.95	2006	2010	2010	1	4
GOLD AH	204	3.49	2001	2011	2011	1	9
VENKATESH V	136	3.57	2003	2011	2011	1	7

Burst detection determines whether a given frequency function has statistically significant fluctuations during a short time interval within the overall time period. It is valuable for citation analysts to detect whether and when the citation count of a particular reference has surged. Table 2 shows that works written by Davenport is the most core works cited in KM. this attention has started since 1998-2005 and 2010-2014. Total citations of him are 928 (317+611). The table also shows that works written by Oleary, Hedlung, and Quinn had more fluctuations during the time and their works were base in KM subject area 16, 11, and 9 years.

If we accept this that citations and cited-half-life show the impact and stability of the theories, we can say that the impact of works written by Davenport, Polanyi and Brown with 928, 650 and 513 citation is more than other core authors of the field, and the stability of Drucker, Schon, Nelson, and Polanyi Theories with 36, 29, 26 and 25 citation half-life is more than other theories.

Accordingly a base author with high Betweenness centrality score is a turning point in a domain. Table 3 shows the centralities of core author of KM.

Table 3

The score of core authors of KM field based on centrality indicator

Number	Author	Centrality
1	Nonaka I	0.25
2	Kogut B	0.2
3	Polanyi M	0.19
4	Simon HA	0.16
5	Grant RM	0.14
6	Applegate LM	0.1
7	Senge PM	0.06
8	Gaines BR	0.05
9	Huber GP	0.04
10	Sprague RH	0.03
11	Bonczek RH	0.03
12	Blanning RW	0.03
13	Binbiasioglu M	0.03
14	Davenport T	0.02
15	Dodgson M	0.02
16	Szulanski G	0.02
17	Teece DJ	0.02
18	Cohen WM	0.02

Based on the table 3 data we can say that the main turning points of the KM is hidden in the works of the authors such as Nanoka, Kogut, Polayni, Simon, Grant and other mentioned authors.

Table 4

The score of core authors of KM field based on Sigma indicator

Number	Author	Sigma
1	Polanyi M	2.38
2	Senge PM	1.94
3	Davenport T	1.91
4	Gaines BR	1.29
5	Dodgson M	1.11

As we said Sigma (∑) is introduced in (Chen, et. Al, 2009a) as a measure of scientific novelty. It identifies scientific publications that are likely to represent novel ideas according to two criteria of transformative discovery. Thus the novelty of core authors of KM such as Polanyi, Sange, Davenport, Gaines and Dodgson is more than all other core authors of the field.

Conclusions

The findings showed that different specialties can be recognized in the KM field. Half of the specialties are interrelated which shows the interdisciplinary nature of the KM fields. The most important cluster is 12th and the role of top KM authors such as Nanoka, Davenport and Polanyi is prominent. The 10th cluster is a Management oriented KM and is dominated by works of Senge, Argris, Quinn and Drucker works. While it seems that 7th cluster be more technology oriented specialty of knowledge management. The prominent core authors of the specialty are Chen, Banerjee, and Salvini.

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