Visualizing the Landscape and Trend of Knowledge Management: 1974 to 2017

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Abstract—**A comprehensive assessment of publication data in the Knowledge Management domain was conducted. By using the related literature in the Science Citation Index (SCI) database from 1974 to 2017, a scientometric approach is used to quantitatively evaluate current research landscape and trend. This shows that Knowledge Management is in the growth period with a maturity of 87.22%, a total of 8121 articles covering 113 countries/territories and the top 3 most productive countries are China, USA and England. There are 4556 research institutes engaged in the research field of "Knowledge Management" and the top 3 most productive institutes are Islamic Azad University, Wuhan University of Technology and Harbin Institute of Technology. Research hotspots, such as performance, system, innovation, firm, information technology, strategy, organization and ontology are shown in a keywords clustering mapping. In addition, keywords with the strongest citation burst, such as Expert System, Organizational Memory, Artificial Intelligence, Decision Support, Social Media, Big Data and Total Quality Management demonstrate the trends of this field. The result provides a dynamic view of the evolution of "Knowledge Management" research landscapes, hotspots and trends from various perspectives which may serve as a potential guide for future research.**

Keywords-Knowledge Management; Scientometrics; Mapping of Knowledge Domain.

I. INTRODUCTION

Knowledge Management (KM) is the process of creating, sharing, using and managing the knowledge and information of an organization which has existed for more than 40 years as a research area [1]. KM is widely used in Management [2], Business Information [3], Science [4], Education [5], Engineering [6] and so on.

In the recent years, scholars conducted a comprehensive review of the research in the field of knowledge management. Corso et al. [7] reviewed and described the different streams and approaches emerging in literature on knowledge management in product innovation. Liao [8] surveyed and classified KM technologies using seven categories as follows: KM framework, knowledge-based systems, data mining, information and communication technology, artificial intelligence/expert systems, database technology, and modeling, together with their applications for different research and problem domains. Chen et al. [9] reviewed the development of knowledge management using a literature review and classification of articles from 1995 to 2004. Bjornson et al. [10]'s systematic review identifies empirical studies of knowledge management initiatives in software engineering, and discusses the concepts studied, the major findings, and the research methods used. Gallupe [11] surveyed the landscape of knowledge management system research and provided a framework for research into the development and use of these systems in organizations. Marra et al. [12] debated on the role of knowledge management in supply chain management by reviewing the published literature. Durst et al. [13] reviewed research on knowledge management in small and medium-sized enterprises to identify gaps in the body of knowledge.

In this paper, a scientometric review of the landscape and trend of published knowledge management research is performed by investigating the scientific outputs, geographical distribution and international cooperation, distribution of institutions and journals with the aim to offer another perspective on the development of research in the field of Knowledge Management. Moreover, innovative methods, such as co-citation analysis, keyword semantic clustering and burst detection were applied, which can vividly reveal the landscape and trends from various perspectives.

The rest of the paper is structured as follows. In Section II, we present the data and methods used. Section III contains the results and discussion. WE conclude this work in Section IV.

II. DATA AND METHOD

A. Data Collection

The bibliographic records used for analysis in this paper were collected from Web of Science (WoS) of Clarivate Analytics on November 15, 2017, and specific search strategy is as follows:

Topics = "Knowledge Management*"

Timespan = All years

Databases = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.

The query resulted in 8121 bibliographic records. The whole records were then retrieved and downloaded for subsequent analysis.

B. Methods

After data collection, cleaning, conversion, deduplication and other operations, a basic analysis with regard to highly productive countries/territories and institutes, highly cited references and highly cited authors was conducted by Microsoft Excel. H-Index and other metrics were calculated

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by a Python script, geographic distribution of scholars was mapped by Google Earth according to author affiliations, network analysis of different type entities such as countries/territories, institutes, categories and keywords was conducted by the scientometric software CiteSpace [14] and VOSViewer [15] with the aim to identify the intellectual structure, hotspots and trends of the Knowledge Management research. Semantic clustering of keywords was conducted based on word2vec [16] and burst detection of keywords was conducted by the algorithm proposed by Kleinberg [17].

III. RESULTS AND DISCUSSION

A. Scientific Outputs of Knowledge Management Research

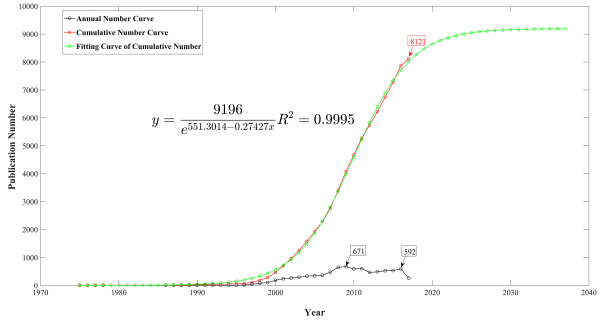

Figure 1. Article Number Curve

Figure 1 shows the number of papers and maturity forecast between 1974 and 2017 in the field of Knowledge Management. The black curve is the annual number of article. The earliest published time is 1974. Henry [18] argued knowledge management as a new concern for public administration. From the curve, we found that a substantial interest in Knowledge Management research did not emerge until 2002, although a few articles related to Knowledge Management were published previously. The highest number of papers arrived at 2009, with 671 articles, accounting for 8.26% of the total number and the average number of articles was 193.4 per year. The red curve is the cumulative number of papers. According to the theory of technology maturity, the cumulative number of documents could be fitted by the Logistic Growth Model [19]. The least squares method for curve fitting is used to get the parameters in the equation, where the blue curve is the result which is described by (1).

$$y = 9196 / (1 + \exp^{551.3014-0.27427x}) \quad (1)$$

Here, x and y denote the year and article number, respectively. According to this, we can divide the development of Knowledge into four stages: infant period (before 2002), growth period (2003-2018), mature period (2019-2024) and stable period (after 2024). According to the above stage division, the research of Knowledge Management in 2017 was in the growth period with a maturity of 87.22%.

B. Characteristics of Geographic Distribution

Figure 2 shows the geographic distribution of countries/ territories in the field of Knowledge Management which was generated from author affiliations. One obvious characteristic is that these research institutes are mainly located in Europe, North America, Southeast Asia and Australia. Institutes in Europe are mainly located in the western region containing countries such as Great Britain, France, Germany and Italy. Countries in North America are mainly represented by the US. Institutes in Southeast Asia are mainly located in China (Mainland), South Korea, Taiwan (Territory) and Japan.

Table I lists the top ten most productive countries/ territories in the field of Knowledge Management. Overall, China is the first most productive, but fifth most influential country in this field, with a total number of 1315 papers (1204 independent papers, 111 internationally collaborated papers), 235 institutes and 2755 citations. Its top five most productive institutes are Wuhan University of Technology (54 papers), The Hong Kong Polytechnic University (50 papers), Wuhan University (48 papers), Harbin Institute of Technology (44 papers) and Chinese Academy of Sciences (39 papers), and Chinas H-Index is 30. USA is the second most productive, but the first most influential country in this field, with a total number of 1098 papers (804 independent papers, 294 internationally collaborated papers), 111 institutes and 22073 citations. Its top five most productive institutes are George Washington University (37 papers), IBM Corporation (20 papers), Purdue University (19 papers), Rutgers University (18 papers) and Illinois State University (17 papers), and USA's H-Index is 72. England is the third most productive and also the third most influential country in this filed, with a total number of 581 papers (393 independent papers, 188 internationally collaborated papers), 157 institutes and 6089 citations. Its top five most productive institutes are Loughborough University (55 papers), Coventry University (39 papers), University of Salford (22 papers), Brunel University (21 papers) and University of Sheffield (20 papers), and its H-Index is 38. Other countries/ territories such as Germany, Australia, Taiwan (territory) also make outstanding contributions in this field.

TABLE I. TOP TEN COUNTRIES/ TERRITORIES IN KM

No.	C/T	TP	IP	CP	TC	HI	TI	BC
1	China	1315	1204	111	275	30	235	0.04
2	USA	1098	804	294	22073	72	111	0.29
3	England	581	393	188	6089	38	157	0.13
4	Germany	407	299	108	1888	21	78	0.09
5	Australia	342	230	112	1762	20	124	0.19
6	Taiwan	322	280	42	5206	39	144	0.02
7	Spain	310	215	95	1833	22	111	0.12
8	Malaysia	287	246	41	803	13	180	0.05
9	Italy	212	154	58	910	17	75	0.10
10	Canada	205	121	84	2167	24	69	0.08

No., Rank By TP; C/T, Country/Territory; TP, Total papers; IP, independent papers; CP, Inter-nationally collaborated articles; TC, Total citations counts; HI, H Index; TI, Total Institutes numbers; BC, Betweenness centrality in the Cooperation Networks (CHINA refers to mainland China).

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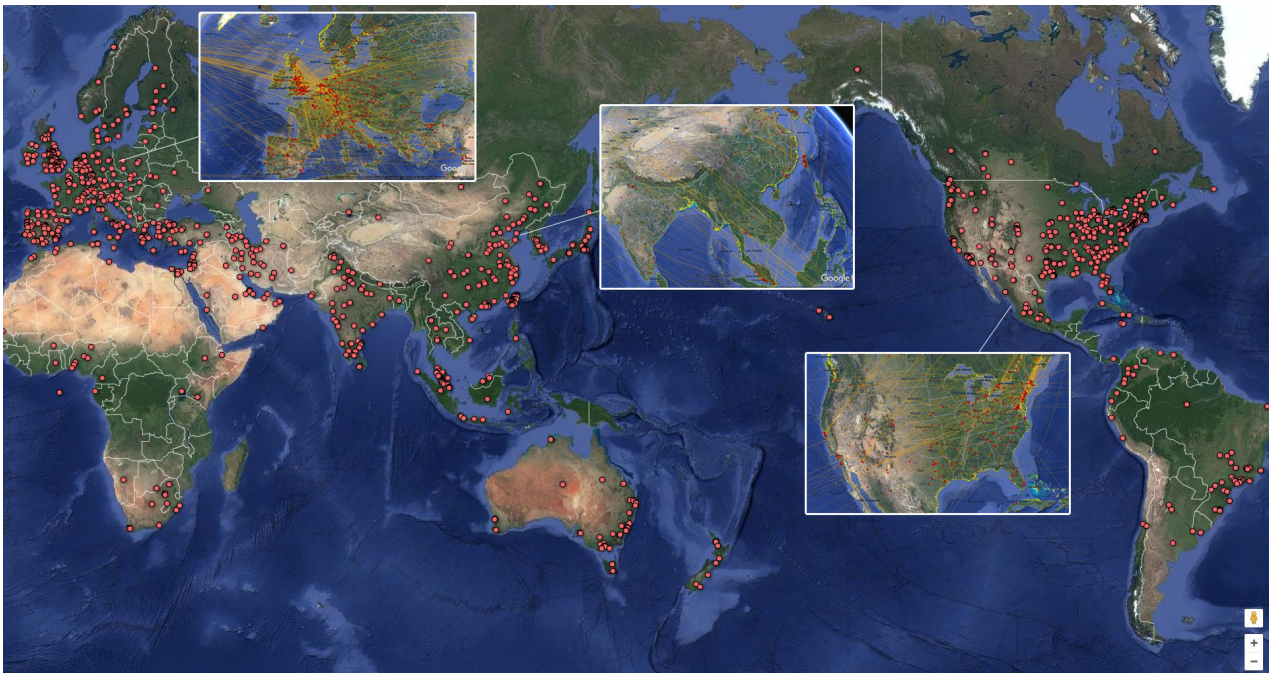

Figure 2. Geographic Distribution of Countries/Territories

C. International Collaborations

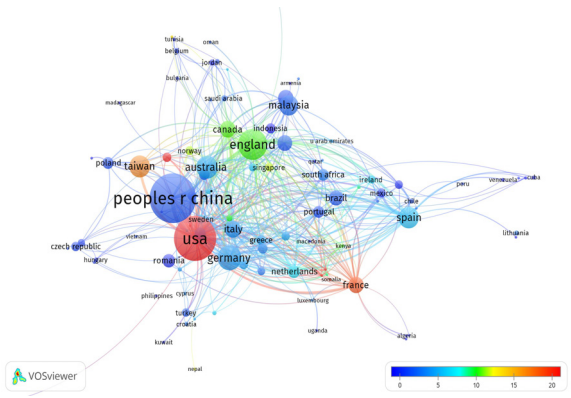

Figure 3. Countries/ Territories Collaboration Network

In order to vividly show the collaboration between countries/ territories, a network was generated by the VOSViewer (Figure 3). The size of the node represents the number of documents, while the color indicates the number of times the node is referenced. In total, there are 113 countries/territories in the field of Knowledge Management. As can be seen, the major contribution of the total output mainly came from three countries, namely, China, USA and England. In order to find the most influential countries in the field, we use the "Burst Detection Algorithm" in CiteSpace to detect the surge in research interest within KM research, and ten countries are found to have citation bursts: USA (119.4374), China (64.0792), Indonesia (29.3474), Germany (24.4142), England (22.4903), Romania (16.0049), India (14.8139), Colombia (14.6504), Poland (13.4845), Australia (12.5315), suggesting that they have abrupt increases of interest in the research of Knowledge Management. Betweenness Centrality metrics provide a computational method for finding pivotal points between different specialties or tipping points in an evolving network [14]. Thus, high betweenness centrality nodes such as USA, Australia, Spain, England indicates that these countries play an important role in this research filed.

D. Characteristics of Institutes

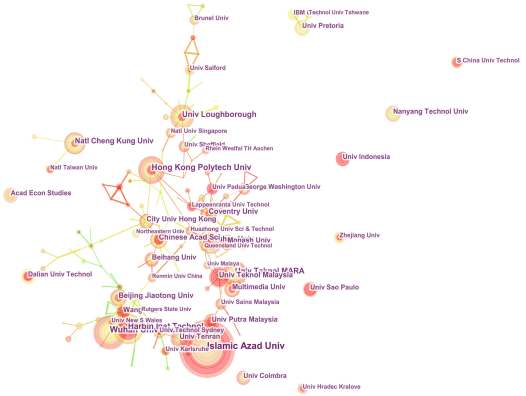

Figure 4. Institutes Co-occurring Network

Overall, a total of 4556 research institutes in the world were engaged in Knowledge Management during the period 1974 to 2017. Figure 4 shows the cooperation network of the institutes. In order to show the core institutions of this field, we filter out the institutions with a small number of publications and get an institute co-occurring network with 256 nodes and 342 links. Obviously, Islamic Azad University takes the first place with a frequency of 75 articles. In second place is Wuhan University of Technology with a frequency of 46 articles. We also notice that China's other institutes, such as Harbin Institute of Technology, The Hong Kong Polytechnic University, Wuhan University and Chinese Academy of Sciences were also on the top of the list. The nodes in the network with red colors are the institutes with strong citation bursts. Obviously, thirteen institutes are found to have citation bursts: Harbin Institute of Technology (11.3197), Wuhan University (10.8479), Universitas Indonesia (10.1611), Islamic Azad University (9.5093), Technological University of Malaysia (8.1657), Dalian University of Technology (7.8935), University of New South Wales (7.5086), University Of Karlsruhe (7.2476), Monash University (7.2389), Multimedia University (7.0823), University of Padua (6.4401), Beijing Jiaotong University (6.1222), Napier University (6.0201). We listed the details in the Table II.

TABLE II. TOP TEN INSTITUTES IN KM

No.	Name	Frequent	Citation Burst	Betweenness	Year
1	Islamic Azad Univ.	75	9.51	0.01	2010
2	Wuhan Univ. Technol.	46	0	0	2006
3	Harbin Inst. Technol.	41	11.32	0	2003
4	Hong Kong Polytech Univ.	39	4.82	0.05	2002
5	Univ Teknol.MARA	34	0	0	2008
6	Univ. Loughborough	34	5.63	0.03	2001
7	Wuhan Univ	32	10.85	0	2007
8	Natl Cheng Kung Univ.	30	4.32	0	2004
9	Univ. Teknol. Malaysia	28	8.17	0.02	2009
10	Coventry Univ.	26	4.68	0.03	2002

E. *Journal Distribution and Co-occurring Network*

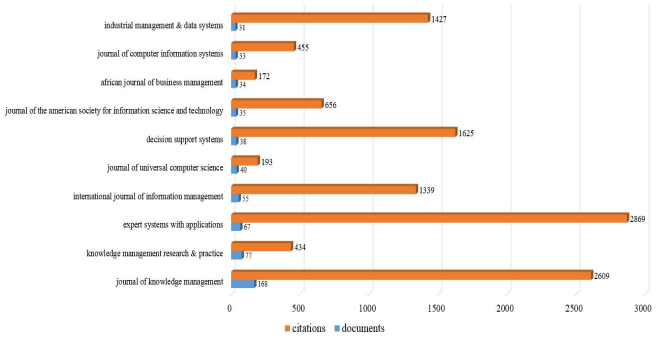

Figure 5. Journal Number Distributions and Citations

The distribution of the Journals in the field of Knowledge Management was displayed in Figure 5. Overall, Journal of Knowledge Management is the most productive one, with a total of 168 papers and 2609 citations, followed by Knowledge Management Research & Practice (77 papers, 434 citations), Expert Systems with Applications (67 papers, 2869 citations), International Journal of Information Management (55 papers, 1399 citations) and so on. We can also conclude that Expert Systems with Applications is the most influential journal, though it has only 67 papers. In order to show the relationship between institutes, a network of co-occurring was generated by VOSViewer and was displayed in Figure 6. Overall, there are 3255 journals in this field and the largest connected component consists of 1710 nodes accounting for a half part of the total nodes, indicating that relationship of journal in this area is getting closer and closer.

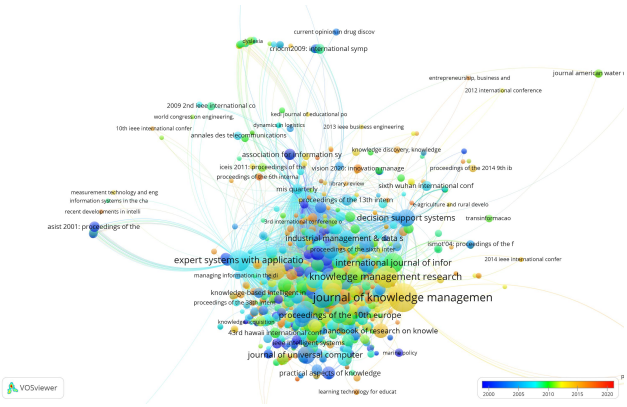

Figure 6. Journal Co-occurring Network

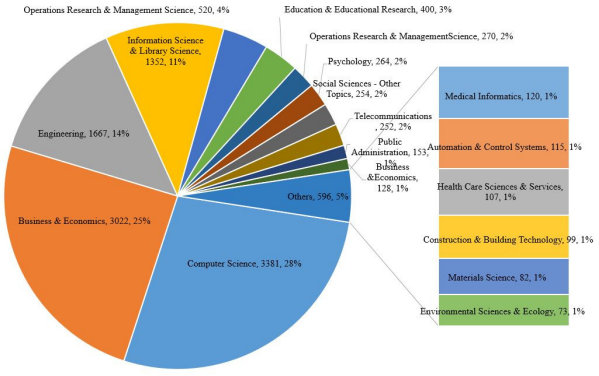

Figure 7. Distribution of Subject Categories

F. *Characteristic of Subject Categories*

The distribution of the subject categories identified by the Institute for Scientific Information (ISI) was analyzed and the result was displayed in Figure 7. The total of 8121 articles covered 50 ISI identified subject categories in the SCI databases. The annual articles of the top ten productive subject categories were analyzed. The top ten categories

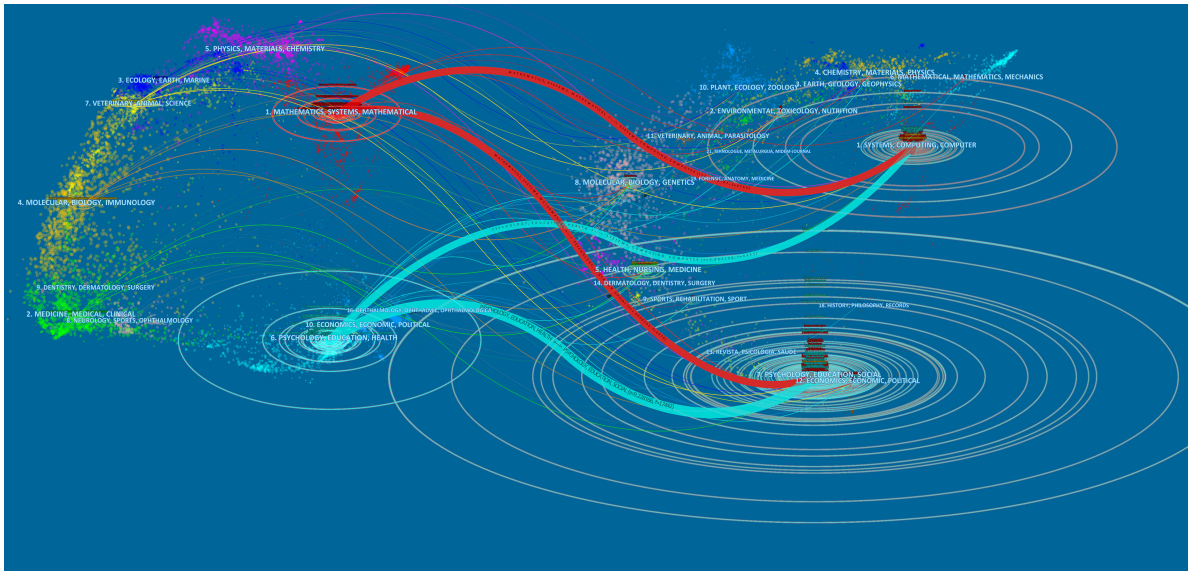

Figure 8. Subject Categories Dual-map

were Computer Science (3381, 28%), Business & Economics (3022, 25%), Engineering (1667, 14%), Information Science & Library Science (1352, 11%), Operations Research & Management Science (520, 4%), Education & Educational Research (400, 3%), Operations Research & Management Science (270, 2%), Psychology (264, 2%), Social Sciences – Other Topics (254, 2%) and Telecommunications (252, 2%).

Figure 8 shows the dual-map overlay of publications in Knowledge Management. Citation links are connected using the z-score. On the left are the source journals, while on the right are the target journals. The two major clusters of source journals are journals in mathematics, systems and mathematical (red), psychology, education, and health journals (blue). We can see that the two major clusters in source journals are cited by the journals in system, computing, computer and the journals in economics, economic, politics which represents the flow of knowledge in this area.

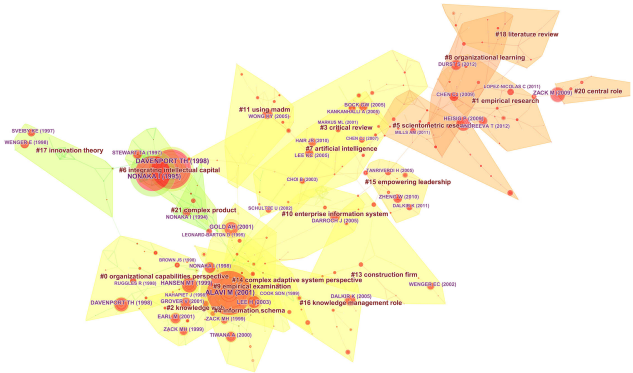

Figure 9. References Co-cited Network

G. *Research Hotspots and Emerging Trends of Knowledge*

Figure 9 shows the document co-cited network. In order to show the core references in the network, G-Index [20] was used to prune the whole network. The pruned network consists of 803 cited references and 1073 co-citation links. In total, there are 20 co-citation clusters identified in the network. In terms of the average age of a cluster, the oldest ones are Clusters #6 and #17, with 1994 as the average year of publication. The most recent Cluster is #8 and #20, with 2010 as the average year of publication. The average year of publication of Cluster #0, the largest one, is 1998.

TABLE III. TOP FIVE LARGEST CLUSTERS

#	Size	Year	Labels
0	44	1998	administration, organizational capabilities
1	42	2009	information technology, empirical research
2	38	1999	transregional effects, knowledge web
3	35	2005	scientometric research, academics
4	35	2000	virtual groups, information schema

Table III lists the top 5 largest clusters in the network. They all have more than 30 members each. Cluster #0 is the first largest one with the labels administration and organizational capabilities. Cluster #1 is the second largest one with the labels information technology and empirical research. Cluster #2 is the third largest one with the labels transregional effects and knowledge Web. Cluster #3 is the largest one with the labels scientometric research and academics. Cluster #4 is the largest one with the labels virtual groups and information schema.

Table IV presents the top ten articles with high cited counts which can represent the research hotspots of Knowledge Management. Alavi et al. [21] provide several important research issues of knowledge management

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TABLE IV. TOP TEN ARTICLES WITH HIGH CITATION COUNTS

No.	Title	Author	Year	Citations
1	Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues	Alavi, M.	2001	2667
2	Knowledge management: An organizational capabilities perspective	Gold, A.H.	2001	1000
3	Successful knowledge management projects	Davenport, T.H.	1998	938
4	Modularity, flexibility, and knowledge management in product and organization design	Sanchez, R.	1996	833
5	A Model of Knowledge Management and the N-Form Corporation	Hedlung, G.	1994	628
6	Knowledge management enablers, processes, and organizational performance: An integrative view and empirical examination	Lee, H.	2003	594
7	Diagnosing cultural barriers to knowledge management	De Long, D.W.	2000	537
8	The state of the notion: Knowledge management in practice	Ruggles, R.	1998	409
9	Knowledge management strategies: Toward a taxonomy	Earl, M.	2001	402
10	From embedded knowledge to embodied knowledge: New product development as knowledge management	Madhavan, R.	1998	393

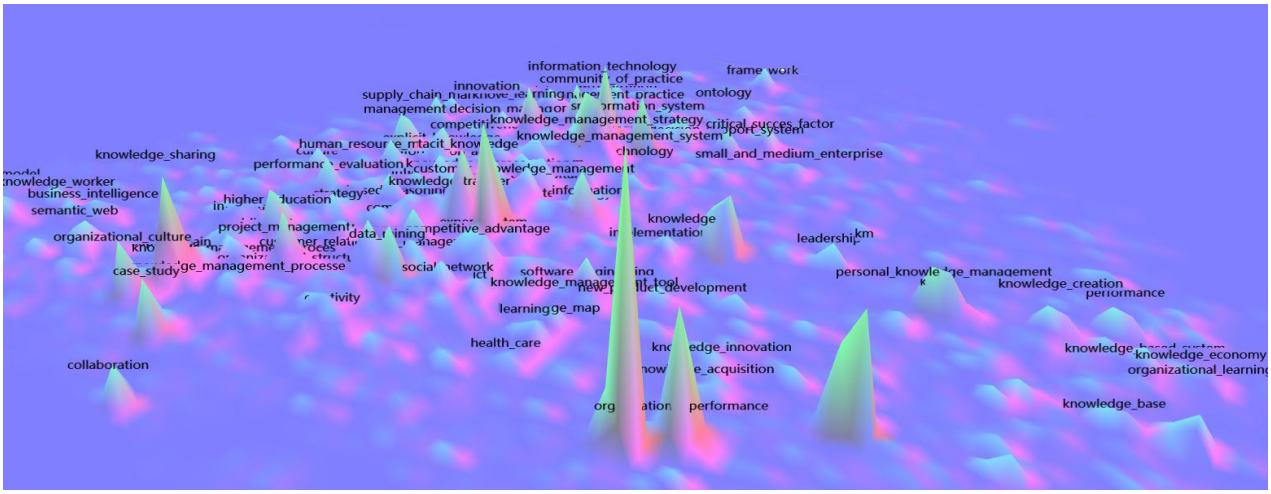

Figure 10. Keyword Co-occurring Network

in different fields with the aim to identifying the important areas for research. Andrew et al. [22] discussed the Knowledge Management from the organizational capabilities perspective through analysis of surveys collected from over 300 senior executives which provide a basis for understanding the competitive predisposition of a firm as it enters a program of knowledge management. Davenport et al. [23] examined the differences and similarities of thirty-one knowledge management projects. Sanchez et al. [24] researched the modularity, flexibility, and knowledge management in product and organization design. Hedlung [25] developed a model of knowledge management and the n-form corporation which was built on the interplay between articulated and tacit knowledge at four different. Lee et al. [26] discussed knowledge management enablers, processes, and organizational performance from an integrative view and empirical examination which can be used as a stepping stone for further empirical research and can help formulate robust strategies that involve tradeoffs between knowledge management enablers. Long et al. [27] diagnosed cultural barriers to knowledge management and concluded four perspectives. Ruggles [28] discussed the state of the notion about Knowledge Management in practice. Earl [29] drew on primary and secondary data to propose a taxonomy of strategies, or "schools" for knowledge management with the aim to guide executives on choice to Initiate KM Projects. Madhavan et al. [30] used the notions of tacit knowledge and distributed cognition as a basis to elaborate that the T-shaped skills, shared mental models, and new product development (NPD) routines of team members, as well as the A-shaped skills of the team leader, are key design variables when creating NPD teams.

In order to find the research landscape about Knowledge Management in detail, a keyword clustering and visualization method based on word2vec [16] was used, and Figure 10 shows the result of such method. Each peak in the figure represents a keyword or topic in the field. The distance between peaks is determined by the semantic similarity between them, and the height of the peaks indicates the importance of the keywords which can be calculated by indicators such as frequency, betweenness centrality and so on. Here, the frequency was chosen as the

basic indicator. From the figure, we can clearly conclude that keywords such as performance, system, innovation, firm, information technology, knowledge management system, strategy, organization, ontology are the research hotspots in this fields. Figure 11 shows the temporal graph of burst keywords detected by CiteSpace, which can be seen as the research front of knowledge management research. According to the order of this emergence of the research front, they are Expert Systems (1975), Organizatorial Memory (1999), Artificial Intelligence（2000），Decision Support (2001) and the latest research fronts are Social Media, Big Data and Total Quality Management.

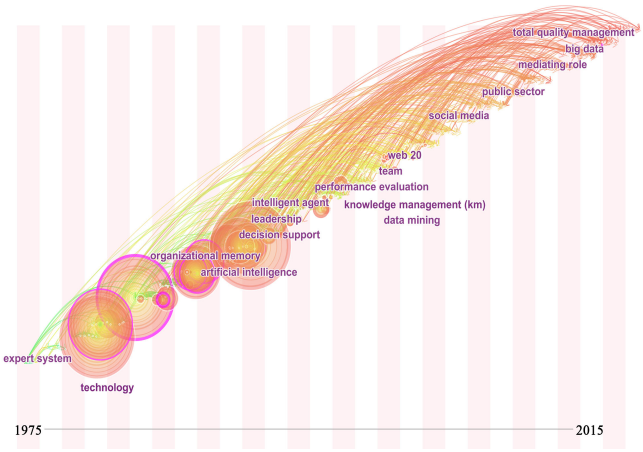

Figure 11. Temporal Graph of Research Fronts in KM

IV. CONCLUSION

This paper presents a comprehensive assessment of publication data in the Knowledge Management domain. A scientometric method was used to quantitatively assess current landscape, research hotspots and trends on Knowledge Management, using the related literature in the Science Citation Index (SCI) database from 1974 to 2017. References about Knowledge Management were concentrated on the analysis of scientific outputs, geographic distribution, institutions, journals and subject categories. Moreover, innovative methods such as co-citation analysis, keyword semantic clustering and burst detection were applied, which can vividly reveal the landscape and trends from various perspectives.

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