

Article

# Visualizing the Academic Discipline of Knowledge Management

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**Abstract:** The aim of this paper was to evaluate the research status of knowledge management (KM) and identify the characteristics of KM in the literature. We selected and studied in detail 7628 original research articles from the Web of Science from 1974 to 2017. Although many studies have contributed to the evolution of the KM domain, our results showed that a comprehensive bibliometric and visualization investigation was required. The literature on KM has grown rapidly since the 1970s. The United States of America, as the original contributing country, has also internationally collaborated the most in this field of study. The National Cheng Kung University has made the highest number of contributions. The majority of authors contributed a small number of publications. Additionally, the most common category in KM research was management. The main publications for KM research include *Journal of Knowledge Management*, and *Knowledge Management Research & Practice*. A keywords analysis determined that “knowledge sharing”, “innovation”, “ontology”, and “knowledge management” were consistent hotspots in knowledge management research. Through a document co-citation analysis, the intellectual structures of knowledge management were defined, and four emerging trends were identified that focus on new phenomenon, the practice of knowledge management, small and medium enterprises (SMEs) management based on knowledge perspective, innovation and performance, and big data-enabled KM. We also provide eight research questions for future studies. Our results will benefit academics, researchers, and research students who want to rapidly obtain an overview of knowledge management research. This study can also be a starting point for communication between academics and practitioners.

**Keywords:** bibliometric; knowledge management; keywords analysis; intellectual structure; emerging trends; knowledge mapping

## 1. Introduction

With the advent of the era of the knowledge economy, knowledge management (KM) has become an important factor for promoting sustainable development of organizations and the economy. KM is also an increasingly important topic in the cross-disciplinary fields of management, computer science, and information science. KM has considerably progressed, attracting attention from researchers, practitioners, and policy-makers [1–3]. KM involves a series of managing activities that mainly concern the adoption, creation, storage, transfer, sharing, and application of knowledge. These activities could be divided into two main macro-processes: knowledge management adoption and knowledge management development [4–7]. The development process includes five phases: creation, storage, transfer, sharing, and application [7–9]. The intellectual antecedents of knowledge management can be traced back to the classical Greek era, which defined the epistemological debate in Western philosophy.

Modern KM research can be traced back to the mid-1970s [10]. Many researchers have contributed to the evolution of knowledge management [10,11]. In the 1980s, some new aspects of knowledge management, including knowledge acquisition, knowledge engineering, and knowledge-based systems, contributed by artificial intelligence research, systematically developed the field of knowledge management [12]. In the 1990s, knowledge management initiatives were flourishing with the help of information technology (IT). KM has helped to address and solve some of the challenges faced by Total Quality Management (TQM) and business process re-engineering [13]. The importance of managing knowledge has become a focus for all types of organizations, as KM is increasingly impacting large companies, SMEs, startups, supply chains, etc. In addition, the development of big data has created new issues for knowledge management [14–19].

Given the depth and breadth of KM practice, the numbers of publications in this field are growing rapidly. Professional journals, such as the *Journal of Knowledge Management*, *Knowledge Management Research & Practice*, *Academy of Management Review*, *Strategic Management Journal*, *Sloan Management Review*, *Harvard Business Review*, and the *Journal of the Association for Information Science and Technology and Scientometrics*, are now dedicated to different aspects of KM [20,21]. Largely due to the widespread use of KM, efforts have been increasingly invested into tracing the change trajectory of KM research, and its disciplinary characteristics.

However, two main problems remain evident in the existing reviews in the field of KM: some studies draw their conclusions based on subjective judgment, which may create controversies due to the limitations of the researcher's personal knowledge, and the previous qualitative analyses, such as bibliometric and scientometric analyses or systematic reviews, have been limited in terms research scope, timeframe, analytical unit, or focus on specific KM themes [11,18,22]. A bibliometric and visualization perspective of prior publications is lacking. Therefore, a bibliometric and visualizing investigation of the global KM research status is important for understanding the research advances and emerging trends. Unlike previous reviews of KM research, we conducted a bibliometric visualization review and obtained an overall picture of this fast-growing field between 1974 and 2017.

The objectives of this study are as follows. First, we wanted to identify the distribution of KM research including publications over time, countries and territories, institutes, authors, sources, and categories in KM-related research. Second, through co-word analysis of the keywords, we wanted to determine the main research topics. Third, we provided an of KM Intellectual Structure by hiring Citespace. Finally, the ultimate goal of this paper was to identify emerging trends.

To achieve these goals, we posed the following eight questions:

- (1) What are the characteristics and growth trends of KM publications?
- (2) What are the international collaborating countries that have the most KM research?
- (3) Where are the active contributors located?
- (4) What are the characteristics of the authorship distribution?
- (5) What are the core KM disciplines and journals?
- (6) What are the core KM research keywords?
- (7) What is the intellectual structure of KM research?
- (8) What are the emerging trends in KM research?

Based on the answers to these eight questions, these results obtained in this study benefit academics, researchers, and management students who want to quickly obtain an overview of knowledge management research. Our findings could assist researchers to better understand the current research progress in the KM domain and to identify the bibliometric characters of KM research. Our results about the emerging trends of KM will help researchers choose valuable research topics in the future. In addition, the research results can be a starting point for communication between academics and practitioners.

## 2. Related Work

Several studies investigated the performance and characteristics of knowledge management, with a wide variety of results. Styhre examined the KM research and found that KM is moving in the progressive direction [23]. Butler analyzed the KM field and suggested that KM could be divided into general, strategy-oriented, information-oriented, human-oriented, and process-oriented perspectives [24]. Lee and Chen visualized the trends in KM with KM data prior to 2006, and determined the 10 most important current research trends in KM [25]. Lee and Chen also revealed the research themes and trends in KM from 1995 to 2010 [26]. Li et al. analyzed the KM research status in China, and obtained some new findings by comparing current with previous KM-related research [27]. Gu found that KM had become an interdisciplinary theory developing on the boundaries of a variety of scientific disciplines [11]. Yogesh et al. provided an overview of 1043 articles for the period of 1974 to 2008, suggesting that KM systems and KM environment were the two most popular topics [28]. Serenko and Bontis ranked the knowledge management and intellectual capital academic journals, and found the top five academic journals in this field [29]. Serenko and Dumay found that the KM discipline is at the pre-science stage and the majority of KM citations exhibited a bimodal citation distribution peak [30]. Serenko applied a meta-analysis technique to integrate the overall findings of KM articles [31]. Akhavan et al. found that the most cited articles in KM were from the United States and the United Kingdom [32]. Considering the literature outlined above, some limits in terms of with the choice of research scope, timeframe, and analytical unit were noted. A bibliometric and visualization perspective of prior publications was also lacking.

Thus, we completed a wider investigation of the challenges faced by KM by profiling a large set of existing KM publications in terms of publication year, author, country, keywords, intelligence structure, and emerging trends. By doing this, we provide a comprehensive investigation of KM research.

## 3. Materials and Methods

The data used for this study were obtained from the Web of Science Core collection database, a Web-based user interface of *Web of Knowledge* developed by Clarivate Analytics. We adapted the same search strategy used by Lee and Chen to search for papers with the term “knowledge management” in titles, abstracts, or indexing terms [25]. As a result, we obtained 19,393 records prior to the end of 2017. For this study, we considered only articles, because they are the higher ranked scientific contributions. Although the reviews receive a greater number of citations, their scientific contribution is less important, and may introduce considerable noise into our analysis because they often contain too many topics [20,21]. After filtering out the less representative record types, the dataset was reduced to 7628 original research articles that were assumed to be in some way related to KM.

Bibliometric analysis is an effective way to investigate and examine performance in one knowledge domain [33]. Bibliometric analysis can be defined as a statistical method of determining the quantitative features of bibliographic information, literature, articles, and journals. The popularity of bibliometric studies is mainly due to the intrinsic characteristics of the raw data. Among the methodological options for an investigation study, bibliometric approaches have received increasing amounts of attention in various areas of research. Bibliometric studies have been completed for information systems, organizational studies, marketing-related subjects, operations management, and strategic management [34]. These works present an overview of the evolution of the publication years, document types, number of citations, most cited papers, influential authors, institutions, and countries. In other studies, visualization tools were used to provide a map of the bibliometric results. Detecting emerging research trends has been a focus for many researchers [35]. Various methods have been advocated for the purpose of detecting emerging research trends, such as historiography mapping [36,37], document co-citation [38], author co-citation [39], co-word analysis [40], and journal mapping [41].

Bibliometric mapping is usually used to display a structural overview of an academic field or a journal [42]. Some widespread mapping techniques have been designed and developed as computer

programs like VOSviewer and Citespace. Compared with other quantitative literature review methods, a bibliometric review is usually used to display the quantitative characteristics of an academic field. Conversely, a systematic review provides an in-depth study and highlights strengths and weaknesses in the literature, evidence research gaps, and identifies appropriate research questions. To achieve objective of this study of investigating and visualizing the global research status in the KM field, we chose the bibliometric and bibliometric mapping method.

In this study, we present a bibliometric profile of KM. In addition, some research tools were used in this study. For example, we used Bibexcel to construct a co-occurrence matrix [43]. Citespace was used for co-citation analysis [44]. Ucinet [45] and Vosviewer [46] were used for social network analysis and visualization and Carrot was used for cluster analysis [47]. Other tools such as Excel were also used for basic statistical analysis and visualization of the bibliometric results. To evaluate the present KM situation, some indicators were used in this paper. For instance, frequency is one of the most commonly used indicators in the bibliometric knowledge domain and is considered the main indicator that highlights the present situation in a research field. Some network indicators were also used in this paper, such as degree centrality and betweenness centrality [45]. The reason for choosing these indicators was that they were also the most commonly used indicators in knowledge network analysis. For the emerging trends analysis, a method was introduced by Chen [44] that combines modularity and a burst index. This method is widely used and has been proven to be able to detect the emerging research trends in other domain. The overall approach and methodology is shown in Figure 1.

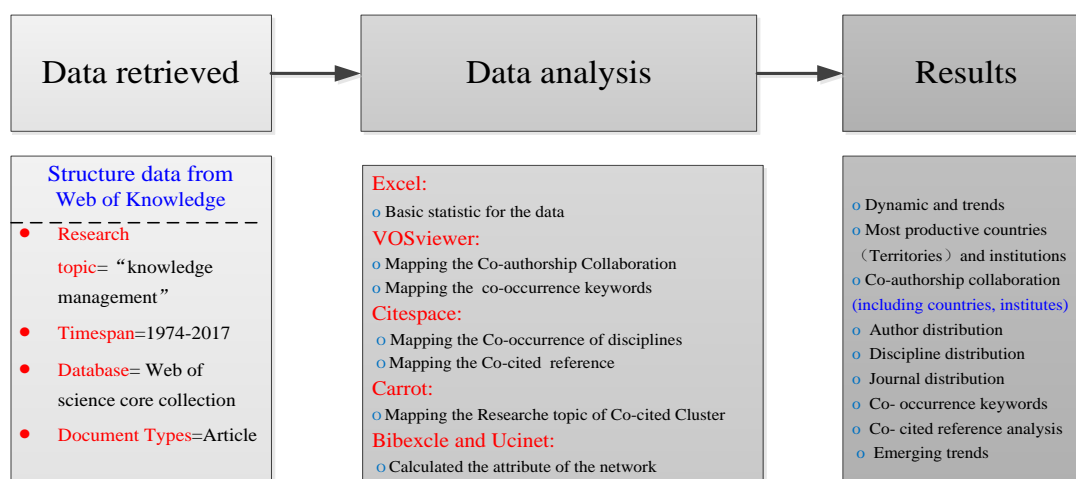


Figure 1. Research methodology.

## 4. Results

### 4.1. Distribution by Publication Year

Table 1 displays several characteristics of KM-related publications based on the year of publication. The annual number of articles and countries and the average number of authors and cited references increased significantly during the period of 1974 to 2017. Through checking the published papers over time, only one article was published in 1974, with an increasing number of KM publications after 1999. In 2012, a peak of 588 articles were published. After 2013, the number of publications steadily declined. Each KM publication had an average of 1.7 authors between 1974 and 1998, whereas the number steadily increased to 2.7 for 1999–2017. The annual number of countries participating in KM research also quickly increased from one country in 1974 to 77 in 2011, whereas the average number of cited references declined from 27.2 from 1974–1998 to 21.8 from 1999 to 2017. The correlation between Times Cited (TC) for an article and the length of time since its publication is shown in Table 1. The average length of an article fluctuated slightly, with an overall average of 13.5 pages.

**Table 1.** Knowledge management (KM) research article characteristics by year from 1974 to 2017.

Publication Year	NP (%) of 7628 Papers	No. Cr (TE)	AV. AU	AV. NR	AV. TC	AV. PG
1974	1 (0.013%)	1	1	37	22	8
1975	4 (0.052%)	1	1	25	1.3	6.3
1976	1 (0.013%)	1	1	48	4	13
1977	1 (0.013%)	1	1	22	6	15
1986	2 (0.026%)	2	1	26	7	18.5
1987	1 (0.013%)	1	1	24	74	12
1988	1 (0.013%)	1	3	30	9	8
1989	4 (0.052%)	2	2	20.8	14.3	11.8
1990	2 (0.026%)	1	2	8	8	5.5
1991	6 (0.079%)	4	2	17.7	3.7	17.3
1992	5 (0.066%)	5	1.8	15.4	1.5	11.2
1993	7 (0.092%)	5	2	27.6	6.6	21.3
1994	7 (0.092%)	7	2	20.6	95	10
1995	12 (0.157%)	4	1.8	22.4	9.8	16.3
1996	15 (0.179%)	7	2.3	28.2	99.1	15.7
1997	38 (0.498%)	9	2	23.7	40.4	12.3
1998	57 (0.747%)	17	2	23.9	61.4	13.4
1999	104 (1.363%)	24	1.9	26.5	54.6	12.0
2000	153 (2.006%)	28	2.0	26.7	40.5	13.5
2001	209 (2.740%)	31	2.3	31.4	45.6	14
2002	290 (3.802%)	40	2.3	25.3	30.3	12
2003	290 (3.802%)	43	2.6	26.2	29.4	13
2004	330 (4.326%)	48	2.8	28.8	24.5	12.6
2005	395 (5.178%)	49	2.7	33.1	28.5	13.9
2006	383 (5.021%)	57	2.6	34.8	26.4	13.7
2007	346 (4.536%)	54	2.6	41.4	24.2	15.4
2008	420 (5.506%)	56	2.6	43.2	19.6	14.1
2009	496 (6.502%)	64	2.6	41.5	21.7	14.0
2010	520 (6.817%)	62	2.7	48.7	18.0	14.5
2011	562 (7.368%)	77	3.0	51.1	15.6	15.1
2012	588 (7.708%)	69	2.8	51.6	10.9	14.8
2013	503 (6.594%)	70	3.2	56.4	10.2	15.4
2014	475 (6.227%)	70	3.0	58.2	8.1	15.0
2015	481 (6.306%)	67	3.2	61.9	4.8	16.0
2016	463 (6.070%)	74	3.1	58.2	1.8	15.4
2017	456 (5.978%)	67	3.1	65.6	0.5	16.4
Total	6285/100%	123	-	-	-	-

Noted: NP = number of publications; No. CR (TE) = number of countries; AV. AU = average number of authors; AV. NR = average numbers of references; AV. TC = average number of Times Cited; AV. PG = average number of pages.

In this study period, the growth in cumulative publications fit an exponential S-shaped function. S-shaped growth is a typical characteristic of a relatively mature stag research field [30]. Figure 2 indicates that KM research areas have entered the mature stage as of 2013.

#### 4.2. Distribution and International Collaboration among Countries (Territories)

A total of 123 countries (territories) participated in KM publication activities from 1974 to 2017. Figure 3 shows the geographical distribution of the important countries (territories). Table 2 ranks the number of articles for each country contributing to KM publications. Notably, an article may be authored by many authors in several different countries. Therefore, the sum of articles published by each country may be larger than the total number of articles. The 1624 institutions in the U.S. published 1763 (25.26%) articles and had the largest number of authored papers. England (territories) was ranked second and Taiwan (territories) ranked third. China contributed 579 (7.6%) articles from 576 institutions and Spain published 553 (7.3%) articles out of 602 institutions.

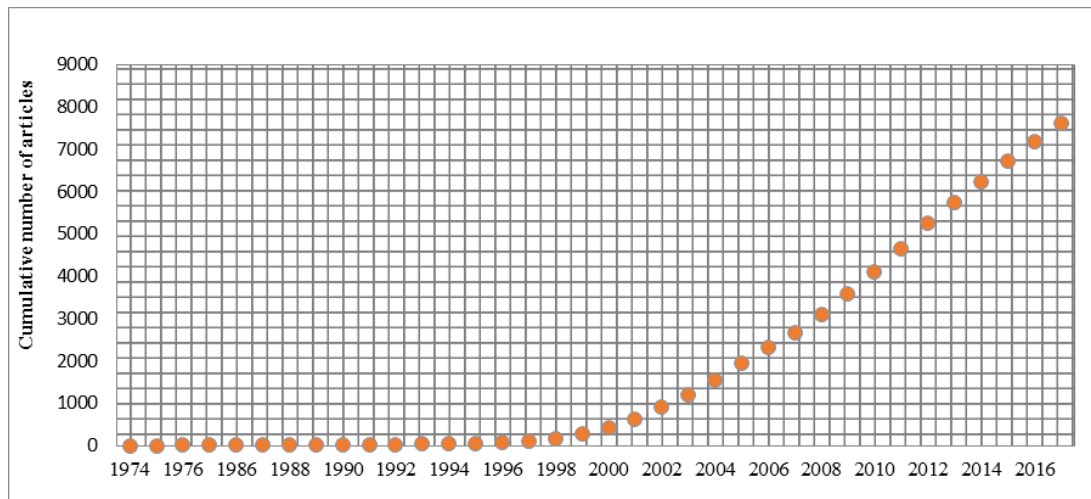


Figure 2. Cumulative growth in knowledge management publications, 1974–2017.



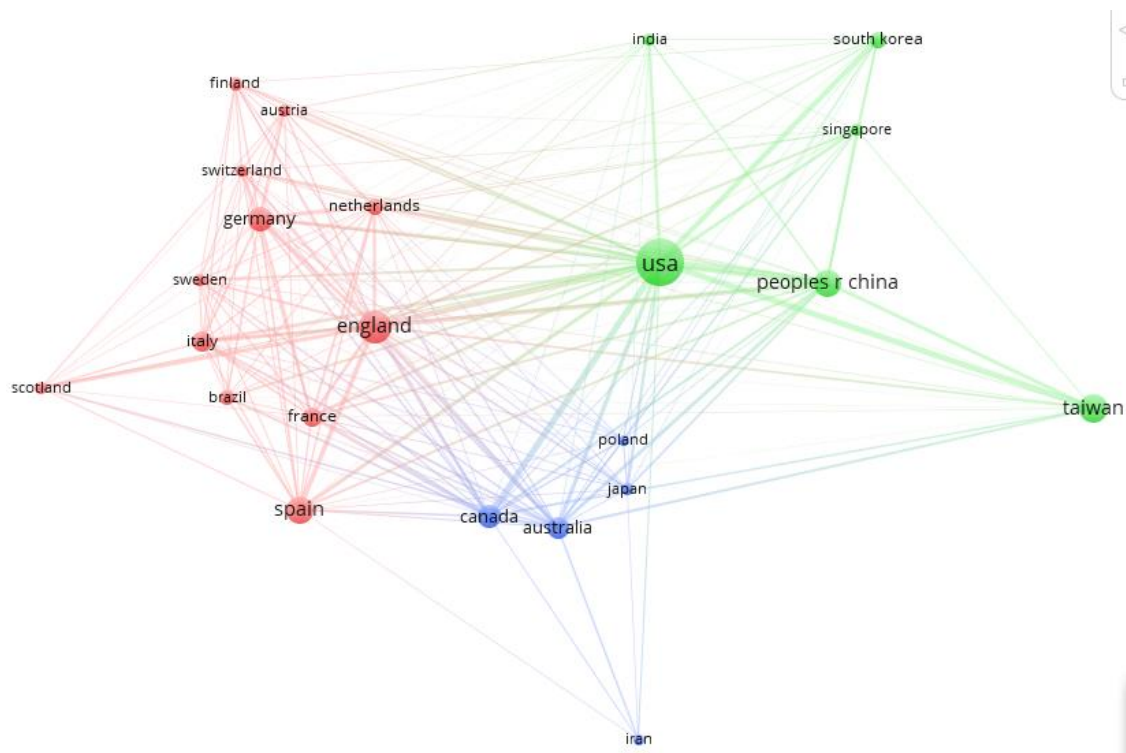
Figure 3. Geographic distribution of KM research articles.

By investigating citations from papers according to country distribution (Table 2), we found U.S.-authored papers were cited by 17,462 articles with 58,283 citations, accounting for 42.2% of all citations. U.S.-authored papers also had the highest average number of citations per article with a frequency of 33.06. The publications from England were next, distantly following the U.S., cited by 13,954 articles with 16,733 (11%) citations. The subsequent countries (territories) include Taiwan, China, and Spain.

International collaboration in science is both a reality and a necessity, and it is in the interest of all nations [48]. A network consisting of nodes with the collaborating countries between 1974 and 2017 is shown in Figure 4. The connection strength that determines the collation frequency between nodes (countries or territories) shows that the U.S. had the closest collaborative relationships with China, Canada, and England. England had the closest collaborative relationships with the U.S., Spain, and China. Taiwan had the closest collaborative relationships with Australia, the U.S., and some Asian countries. Germany had the closest collaborative relationships with European countries, such as Austria, England, and France, and China, the fifth-ranked country, had the closest relationships with the U.S., England, and Germany.

**Table 2.** Knowledge management (KM) research country (territory) ranked by the number of articles (>100 publications).

Rank	Country (Territory)	No. of Articles (%)	Citations (%)	Average	Citing Articles (%)	Institution
1	U.S.	1763 (23.1%)	58,283 (42.2%)	33.06	17,462 (48.8)	1624
2	England	837 (11 %)	16,733 (12.1%)	19.99	13,953 (18.3)	856
3	Taiwan	595 (7.8%)	10,428 (7.6%)	17.53	8028 (10.5)	233
4	China	579 (7.6%)	8924 (6.5%)	15.41	7461 (9.8)	576
5	Spain	553 (7.3%)	7485 (5.4%)	13.54	6352 (8.3%)	602
6	Germany	462 (6.1%)	4707 (3.4%)	10.19	4385 (5.8%)	735
7	Canada	395 (5.2%)	9937 (5.7%)	20.09	7124 (9.3%)	507
8	Australia	371 (4.9%)	5499 (4.0%)	14.82	5142 (6.7%)	367
9	Italy	331 (4.3%)	3843 (2.8%)	11.61	3564 (4.7%)	471
10	France	279 (3.7%)	3758 (2.7%)	13.47	3729 (4.9%)	533
11	Netherlands	223 (2.9%)	3918 (2.8%)	17.57	3687 (4.8%)	394
12	South Korea	220 (2.9%)	3895 (2.8%)	17.7	3394 (4.5%)	208
13	Brazil	185 (2.4%)	1190 (0.9%)	6.43	1148 (1.5%)	310
14	Finland	136 (1.8%)	1819 (1.3%)	13.38	1680 (2.2%)	130
15	Japan	126 (1.7%)	2540 (1.8%)	20.16	2471 (3.2%)	209
16	India	124 (1.6%)	1194 (0.9%)	9.63	1121 (1.5%)	254
17	Switzerland	119 (1.6%)	1906 (1.4%)	16.02	1846 (2.4%)	308
18	Singapore	117 (1.5%)	3321 (2.4%)	28.38	2985 (3.9%)	159
19	Sweden	113 (1.5%)	2350 (1.7%)	20.80	2246 (2.9%)	267
20	Scotland	111 (1.5%)	2011 (1.5%)	18.12	1936 (2.5%)	157
21	Austria	110 (1.4%)	1170 (0.8%)	10.64	1161 (1.5%)	221
22	Iran	102 (1.4%)	616 (0.4%)	6.04	566 (0.7%)	91
23	Poland	101 (1.3%)	638 (0.5%)	6.32	610 (0.8%)	165



**Figure 4.** International collaboration network of the top 23 countries in KM research. The network was created using VOSviewer. The thickness of the linking lines between two countries is directly proportional to their collaboration frequency.

Table 3 shows the collaboration frequency distribution of papers from the main nations in the KM field. Tables 2 and 3 indicate that the USA is not only the original contributing country, but also the

largest international collaborating country. England is a close second with 377 collaborations compared with the rank of the published number of articles. China and Australia rose in the rankings in terms of international collaboration. However, an opposite trend was observed in Taiwan, ranking fourth. Spain maintained a stable ranking, at fifth place. Table 3 also presents a summary of the Ucinet statistical results of four common parameters of each country: degree centrality, betweenness centrality, effective size, and constraint [33].

Degree centrality is defined as the number of links incident upon a node. It is a count of the number of ties directed to the node. In an international collaboration network, degree centrality often interpreted as a form of popularity or gregariousness. Betweenness centrality, a centrality measure within a graph, quantifies the number of times a node acts as a bridge along the shortest path between two other nodes. In an international collaboration network, the country or institution with a high probability of occurring on a randomly chosen shortest path between two randomly chosen vertices will have high betweenness. From Table 3, the U.S. and Canada had the highest degree centrality, whereas England, Australia, Italy, the Netherlands, Spain, and Sweden were placed second with 21, and China and Switzerland were ranked third.

Betweenness centrality, an indicator for measuring nodes' control capacity over the network, also showed the USA and Canada played an important role in the top 23 international collaboration network. The other two parameters, effective size and constraint, confirmed the important role of the USA, Canada, and England.

**Table 3.** A social network analysis of the international collaboration network of the top 24 countries.

Country	NO.ICA	NO.ICC	DC	BC
USA	596	77	22	11.705
England	377	68	21	4.339
Taiwan	99	24	14	0.545
China	249	42	20	2.695
Spain	195	68	21	10.032
Germany	165	47	19	2.311
Canada	180	61	22	11.705
Australia	184	49	21	10.973
Italy	114	56	21	4.339
France	122	51	19	2.1
The Netherlands	104	43	21	4.339
South Korea	67	26	14	1.111
Brazil	49	44	19	1.837
Finland	45	29	14	1.703
Japan	46	38	19	6.607
India	42	46	18	0.907
Switzerland	62	52	20	3.231
Singapore	61	34	19	1.889
Sweden	58	48	21	4.339
Scotland	50	30	12	0.182
Austria	47	34	18	2.404
Iran	29	13	5	0
Poland	31	34	18	0.907

Note: NO.ICA = number of international collaboration articles, NO.ICC = number of international collaboration countries, DC = degree centrality, and BC = betweenness centrality.

In a comprehensive view, the collaboration mainly appears in high yield and developed countries. Previous studies indicated cooperation with foreign institutions did not achieve high cited papers. International cooperation does not embody high influence, but it has a very important impact on small and developing countries [29,32]. Therefore, small and developing countries should strengthening international cooperation to improving the publications influence.



### 4.3. Institution Distribution and Collaboration

A total of 4801 institutions participated in KM-related research, with 66.8% participating only once, 12.2% participating twice, and 22% participating more than twice. The top 25 of the most productive institutions are displayed in Table 4. National Cheng Kung University had the highest number of publications with 82 papers, followed by Hong Kong Polytechnic University with 77 papers, and the City University of Hong Kong ranked third with 56 papers. The subsequent countries include the National University of Singapore and the University of Cambridge. Simultaneously, the cited numbers for each paper are also displayed in Table 4. Harvard University was cited the most with 4263 citations, and the average number of times cited was 121.8. The University of Illinois followed closely with 2685 citations and with an average number of times cited of 63.9. The City University of Hong Kong ranked third with 2435 citations and an average number of times cited of 43.5.

**Table 4.** The most productive institutions for KM articles.

Rank	Institution	Country	Article	% of 7628	NO.TC	AV.TC
1	National Cheng Kung University	Taiwan	82	1.1%	1419	17.3
2	The Hong Kong Polytechnic University	China	77	1.0%	1542	20
3	City University of Hong Kong	China	56	0.7%	2435	43.5
4	National University of Singapore	Singapore	54	0.7%	2186	40.5
5	University of Cambridge	England	51	0.7%	1553	30.5
6	Universidad de Granada	Spain	48	0.6%	660	13.8
7	National Chiao Tung University	Taiwan	44	0.6%	902	20.5
8	The University of Manchester	England	44	0.6%	857	19.5
9	Nanyang Technological University	Singapore	42	0.6%	518	12.3
10	University of Illinois	USA	42	0.6%	2685	63.9
11	National Taiwan University	Taiwan	41	0.5%	900	22
12	Loughborough University	England	41	0.5%	887	21.6
13	University of Toronto	Canada	41	0.5%	1737	42.4
14	Polytechnic University of Valencia	Spain	39	0.5%	400	10.3
15	Universidad Carlos III de Madrid	Spain	38	0.5%	1032	20.2
16	University of Murcia	Spain	38	0.5%	884	23.3
17	McMaster University	England	37	0.5%	936	25.3
18	National Sun Yat-sen University	Taiwan	37	0.5%	1059	28.7
19	Cranfield University	England	36	0.5%	800	22.2
20	The University of Arizona	USA	36	0.5%	652	18.1
21	University of Warwick	England	36	0.5%	917	25.5
22	Harvard University	USA	35	0.5%	4263	121.8
23	Indiana University	USA	35	0.5%	1353	38.7
24	University of California	USA	35	0.5%	1930	55.1
25a	Korea Advanced Institute of Science & Technology	South Korea	33	0.4%	1654	50.1
25b	National Tsing Hua University	Taiwan	33	0.4%	543	16.5

Note: NO.TC = number of citations, AV.TC = average number of citations.

Then the top 297 institutions with more than or equal to 10 publications were chosen for our collaboration network analysis. The collaboration network map displayed in Figure 5 was created using VOSviewer. In the collaboration analysis, we were concerned about the collaboration frequency between two institutions. In Figure 5, the thickness of the linking lines between the two institutions is directly proportional to their collaboration frequency.

In the network map, the centrality of a node representing an institution is a graph-theoretical property that quantifies the importance of the node's position in a network. Table 5 presents a summary of the statistical results obtained using Ucinet. The statistical results of two common centralization indexes, degree centrality and betweenness centrality, for each institution qualitatively confirms the above findings.

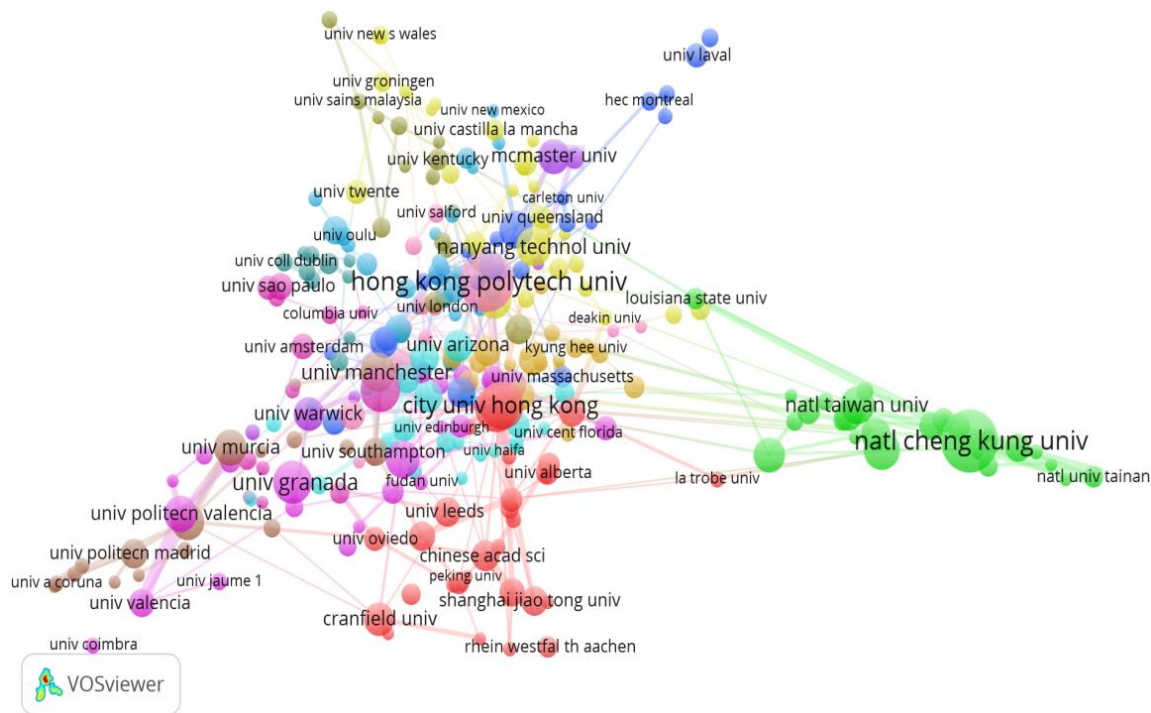


Figure 5. Collaboration network for institutions with more than two articles published contains 791 nodes.

Table 5. A social network analysis of the collaboration network of the top 16 KM research institutions.

Rank	Research Institution	Degree Centrality	Research Institution	Betweenness Centrality
1	City University of Hong Kong	44	City University of Hong Kong	1042.8
2	Aalto University	31	National University of Singapore	710.0
3	Chinese Academy of Sciences	31	University of Cambridge	451.0
4	Boston College	29	Indiana University	399.5
5	Brunel University	29	The Hong Kong Polytechnic University	356.3
6	Carnegie Mellon University	29	Chinese Academy of Sciences	352.0
7	National University of Singapore	29	The University of Arizona	338.7
8	Brigham and Women’s Hospital	28	Carnegie Mellon University	334.4
9	Arizona State University	27	Aalto University	331.7
10	Beihang University	27	University of Illinois	331.3
11	Boston University	27	Brunel University	325.3
12	Aston University	26	Arizona State University	308.4
13	Auburn University	25	Boston University	292.1
14	Cardiff University	25	Universitat de Barcelona	289.3
15	BI Norwegian Business School	24	The University of Maryland	274.0
16	Chang Jung Christian University	24	University of Oxford	273.5
17	Chung Hua University	24	Brigham and Women’s Hospital	266.0
18	Universities in Asia	23	Beihang University	218.0
19	University of Cambridge	23	Penn State University	216.0
20a	Bar Ilan University	22	National Cheng Kung University	214.2
20b	Indiana University	22	University of Warwick	202.3

From Table 5, City University of Hong Kong was ranked first for degree centrality. Aalto University was second place with a degree centrality value of 710, and the Chinese Academy of Sciences ranked third. Compared with the rank of the betweenness centrality, City University of Hong Kong was not only the first-ranked country in terms of degree centrality, but also had the highest betweenness centrality. The National University of Singapore ranked second and University of Cambridge ranked third.

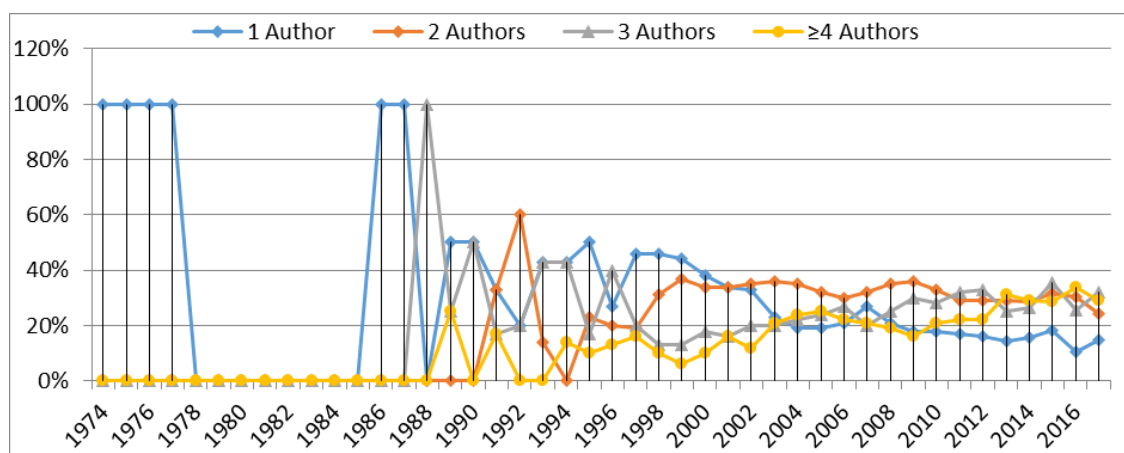
#### 4.4. Authorship Distribution

The total number of authors who contributed to the output set was 15,380. From 1974 to 2017, the average number of authors per article was 2.8. Table 6 shows the distribution of the number of authors with different numbers of articles. The large majority of authors contributed a very small number of publications, and 12,409 authors had only one article, 1820 authors had two articles, and 578 authors published three articles. The most productive author in the field KM articles was Chen from National Cheng Kung University. The second most productive author was Bontis from McMaster University. The third most productive author is Chen from National Cheng Kung University. Gottschalk and Serenko were ranked fourth, from Lakehead University and BI Norwegian Business School, respectively.

**Table 6.** The distribution of number of author with different numbers of articles.

NO.AU	1	1	1	2	2	1	2	5	7	5	11	15	19	26	41	41	125	328	14,808
NO.AR	25	21	20	19	18	17	15	14	13	12	11	10	9	8	7	6	5	4	≤3

Figure 6 displays the articles with number of authors by years. An upward trend was observed in the number of authors per article. The output of single-author papers is waning; the rate of single authorship had fallen drastically in KM research. Of the top 100 highly cited papers, single-author papers accounted for 27%. Although previous research indicated a strong positive correlation exists between the number of authors and the number of quotes, the higher the number of authors, the more often they are cited [30]. Additionally, the single-authored paper may be endangered in many fields, but this research still provides the methods and means for advancing research.



**Figure 6.** The percentage of articles with different numbers authors by year.

#### 4.5. Distribution of Subject Categories

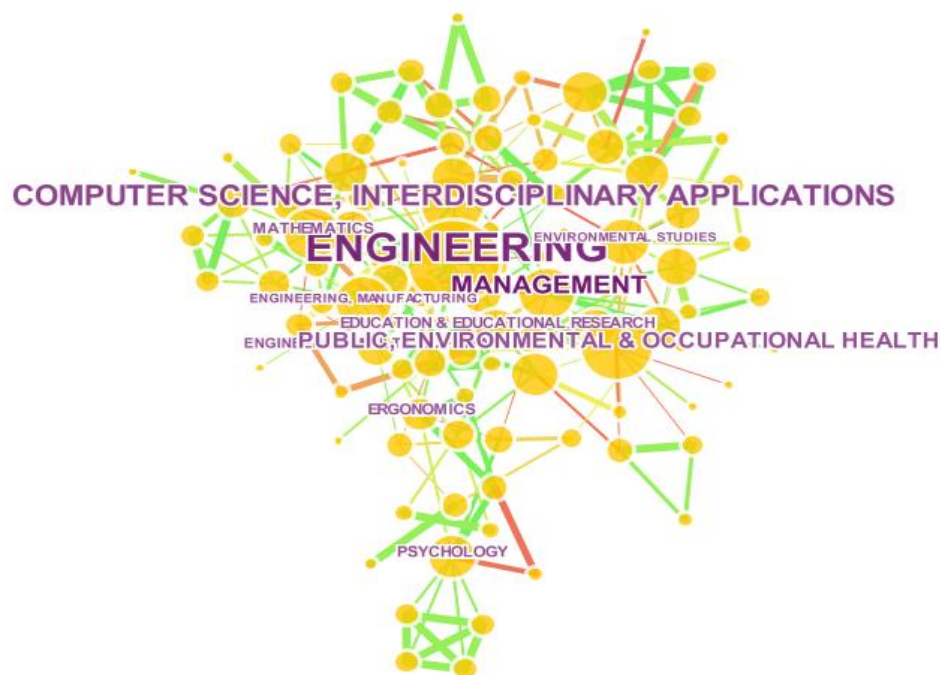
Table 7 displays the top 30 KM categories ranked in terms of the number of publications. The most common category was Management with 2334 records, followed by business economics with 1723 records, and Computer Science Information Systems with 1349 records.

Figure 7 shows a betweenness centrality network of these categories by using Citespace after being simplified with Minimum Spanning Tree network scaling, which retains the most salient connections. The nodes represent a category in which the number of articles had high betweenness centrality. From Table 8, the centrality of the Engineering, Computer Science, Interdisciplinary Applications, Management, Public, Environmental, and Occupational Health, and Psychology categories are notable. Burst, an indicator used to detect emerging trends, was used to detect emerging KM research subject

categories. From Table 8, Computer Science, Theory, and Methods was ranked first with a burst value of 119.2, followed by Computer Science, Artificial Intelligence, and Computer Science. This means that KM research belonging to these three categories has been rapidly increasing in recent years.

**Table 7.** The top 30 KM categories ranked by the number of publications.

Subject Category	Records	% of Total
Management	2334	30.6%
Information Science Library Science	1723	22.6%
Computer Science Information Systems	1349	17.7%
Computer Science Artificial Intelligence	1050	13.8%
Operations Research Management Science	782	10.2%
Business	704	9.2%
Computer Science Interdisciplinary Applications	589	7.7%
Engineering Industrial	466	6.1%
Computer Science Theory Methods	461	6.0%
Computer Science Software Engineering	392	5.1%
Engineering Electrical Electronic	361	4.7%
Engineering Manufacturing	312	4.1%
Engineering Multidisciplinary	305	4.0%
Engineering Civil	168	2.2%
Education Educational Research	160	2.1%
Computer Science Cybernetics	154	2.0%
Economics	151	2.0%
Medical Informatics	151	2.0%
Health Care Sciences Services	124	1.6%
Environmental Sciences	109	1.4%
Social Sciences Interdisciplinary	97	1.3%
Planning Development	94	1.2%
Telecommunications	93	1.2%
Public Environmental Occupational Health	89	1.2%
Psychology Multidisciplinary	83	1.1%
Ergonomics	81	1.1%
Environmental Studies	74	1.0%
Construction Building Technology	71	0.9%
Automation Control Systems	67	0.9%



**Figure 7.** Disciplines involved in KM.

**Table 8.** The betweenness centrality distribution and burst value of the KM subject.

Rank	Rank by Betweenness Centrality		Rank by Burst	
	Subject	Betweenness Centrality	Subject	Burst
1	Engineering	0.41	Computer Science, Theory, and Methods	84.68
2	Computer Science, Interdisciplinary Applications	0.31	Computer Science, Artificial Intelligence	78.32
3	Management	0.25	Computer Science	62.86
4	Public, Environmental, and Occupational Health	0.23	Computer Science, Software Engineering	30.63
5	Psychology	0.16	Computer Science, Interdisciplinary Applications	16.05
6	Mathematics	0.16	Engineering, Multidisciplinary	14.57
7	Education and Educational Research	0.16	Science and Technology—Other Topics	14.54
8	Ergonomics	0.16	Psychology, Experimental	13.8
9	Engineering, Multidisciplinary	0.14	Computer Science, Information Systems	12.25
10	Engineering, Manufacturing	0.13	Environmental Sciences	12.04
11	Environmental Studies	0.12	Green and Sustainable Science and Technology	11.7
12	Psychology, Applied	0.12	Environmental Studies	10.9
13	Science & Technology—Other Topics	0.11	Mathematical and Computational Biology	8.29
14	Environmental Sciences and Ecology	0.1	Psychology, Multidisciplinary	8.21
15a	Engineering, Chemical	0.1	Psychology	8.17
15b	Agriculture	0.1		

#### 4.6. Journal Distribution

KM research was published in 1558 journals. The top 20 journals are displayed in Table 9. Knowledge management research publications were highly concentrated in these top journals and approximately one-third of the articles were found in these most productive journals. This is a phenomenon that follows Bradford's law and is consistent with observations in other fields. Of these top 20 journals, 1.3% of the 1558 journals had published 2449, or 32.1%, of the 7628 total articles. The major KM research journals include *Journal of Knowledge Management*, *Knowledge Management Research & Practice*, *Lecture Notes in Computer Science*, *Lecture Notes in Artificial Intelligence*, *Expert Systems with Applications*, *International Journal of Technology Management*, *Decision Support Systems*, and *Journal of Universal Computer Science*, with more than 100 articles each.

**Table 9.** The top 20 knowledge management publication journals.

Rank	Source Title	Records	% of Total
1	Journal of Knowledge Management	418	5.5%
2	Knowledge Management Research & Practice	244	3.2%
3	Lecture Notes in Computer Science	240	3.1%
4	Lecture Notes in Artificial Intelligence	222	2.9%
5	Expert Systems with Applications	198	2.6%
6	International Journal of Technology Management	139	1.8%
7	Decision Support Systems	109	1.4%
8	Journal of Universal Computer Science	104	1.4%
9	International Journal of Information Management	98	1.3%
10	Industrial Management Data Systems	94	1.2%
11	Information Management	64	0.8%
12	Knowledge Based Systems	62	0.8%
13	Journal of Computer Information Systems	61	0.8%
14	Journal of Information Science	60	0.8%
15	Kybernetes	59	0.8%
16	Journal of the American Society for Information Science and Technology	58	0.8%
17	Journal of Business Research	56	0.7%
18	Management Decision	55	0.7%
19	Computers In Human Behavior	54	0.7%
20	International Journal of Production Research	54	0.7%

#### 4.7. Keyword Co-Word Network

Co-word analysis is based on the theory that research fields can be characterized and analyzed based on patterns of keyword usage in publications, which has been successfully used for examining the dynamic evolution of science [41]. Co-word analysis is a content analysis technique that is effective for mapping the strength of the association between keywords in textual data. The network map based on co-word analysis represents the search topics of a specific discipline, which is especially appropriate for describing the development of multidisciplinary fields that combine more complex knowledge. A prior study confirmed the reliability and adequacy of the co-word method for mapping the structure of a scientific field [49], which satisfactorily identified groups of research themes and the process by which fields evolved. In this study, we analyzed a total of 7628 published articles related to KM extracted from the ISI database for the period of 1974 to 2017. After processing, we obtained 13,012 keywords. Most keywords appeared only on one occasion, and only 32 keywords appeared more than 50 times. Table 10 shows the most important keywords ranked by frequency. From Table 10, Knowledge Management, with an occurrence frequency of 3401, was ranked first, followed by keywords Knowledge Sharing, Innovation, Ontology, and Knowledge Management Systems (KMs).

In the introduction, we defined the concept of knowledge management. Here, we introduce other main concepts. Knowledge sharing is an activity through which knowledge, namely information, skills, or expertise, is exchanged among people, friends, families, communities, or organizations. In the KM domain, many studies discussed the different aspects of knowledge sharing. Innovation, consistent with the OECD definition, is defined as a new or significantly improved product (a good or service), process (production or delivery method), marketing method, or managerial method [50]. In the KM field, many studies discussed the relationship between KM and innovation and found that knowledge management plays an important role in innovation. Ontology, a useful technology for KMs or KM identification, storage, and knowledge integration, has also received considerable attention from researchers and practitioners [51]. Knowledge management systems (KMs) can be defined as an information system used to collect, process, and sharing the knowledge, promoting the learning, re-use, and innovation of knowledge, and strengthening the core competence of the organization. Specifically, according to the literature, KMSs are divided into two groups: IT-based tools defined in the literature as KM-Tools, and the organizational practices defined as KM-practices [10,52–54].

**Table 10.** The most important key words ranked by frequency with more than 25 uses.

Author Keyword	Frequency	Author Keyword	Frequency
knowledge management	3401	case study	83
knowledge sharing	371	semantic web	79
innovation	245	data mining	78
Ontology/ontologies	268	knowledge acquisition	77
knowledge management systems	178	communities of practice	75
knowledge	160	collaboration	73
organizational learning	156	project management	71
knowledge transfer	174	social capital	67
intellectual capital	121	organizational performance	66
knowledge creation	115	absorptive capacity	64
tacit knowledge	98	performance	63
information management	95	competitive advantage	58
information technology	94	management	57
information systems	93	new product development	56
organization culture	87	Web 2.0	56
learning	83	trust	

Then the top 835 keywords with a frequency greater than or equal to five were chosen for our co-occurrence network analysis. The co-word network map displayed in Figure 8 was with VOSviewer. In the co-occurrence keyword analysis, we investigated the co-occurrence frequency of two co-occurrence

keywords. The higher the co-occurrence frequency of the two words, the closer the relationship between them, which is represented by the location of the two words. The size of the node represents the frequency of the keyword co-occurrence with other keywords. We drew the following conclusion that Knowledge Sharing has a higher co-occurrence frequency with Innovation, Knowledge Creation and Ontology have a higher co-occurrence frequency with Algorithm and Ontology Change Management, and Knowledge has a higher co-occurrence frequency with Management and Competitive Advantage (Figure 8).

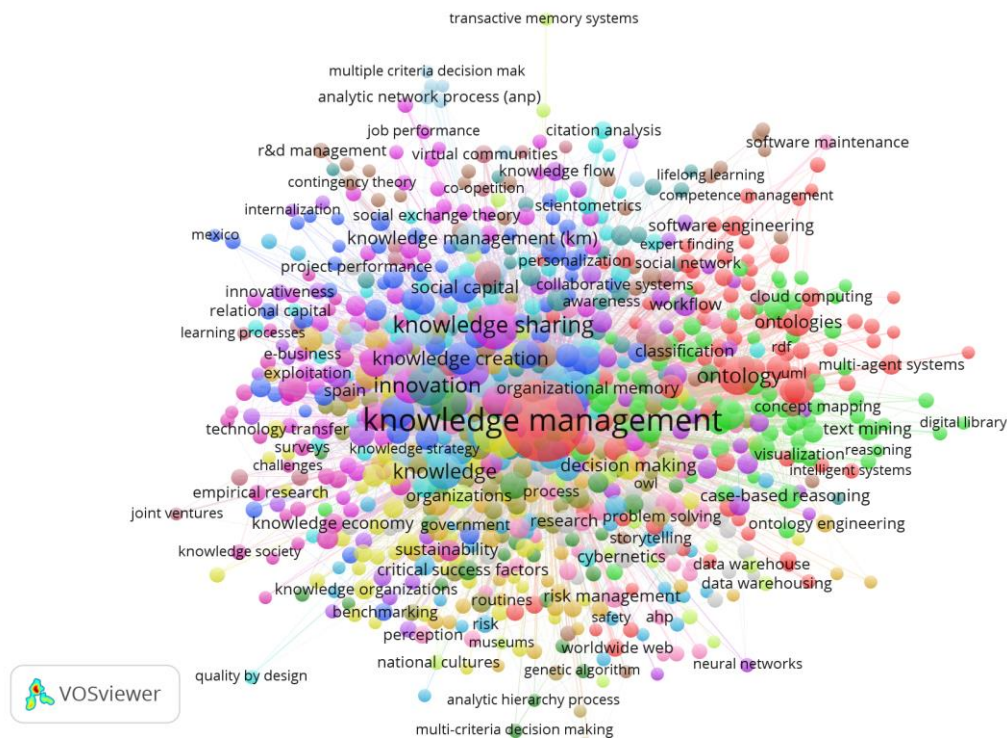


Figure 8. The co-words network of author keywords.

To statistically quantify the importance of each keyword within the co-word network, we used social network analysis. Table 11 presents a summary of the statistical results obtained using the Ucinet too. We ranked the keywords according to degree centrality and Freeman’s betweenness centrality. The degree centrality indicates Knowledge Management, Knowledge Sharing, Innovation, Knowledge Transfer, and Organizational learning play an important role in KM research. Betweenness centrality confirmed the degree centrality analysis result, and highlights the keyword ontology.

Table 11. Keywords by degree centrality, betweenness centrality, and effective size.

Keyword	Degree Centrality	Keyword	Betweenness Centrality
knowledge management	804	knowledge management	409,205.3
knowledge sharing	323	knowledge sharing	33,225.5
innovation	248	innovation	17,793.34
knowledge transfer	194	ontology	10,521.03
organizational learning	185	knowledge transfer	10,416.32
knowledge	184	organizational learning	8946.413
ontology	176	knowledge	8879.887
knowledge creation	158	knowledge management systems	6898.824
knowledge management systems	155	knowledge creation	6300.001
learning	148	learning	5458.257

Table 11. Cont.

information systems	136	information systems	5039.425
tacit knowledge	134	tacit knowledge	4859.399
collaboration	127	information management	4369.465
information management	122	collaboration	4126.945
information technology	119	information technology	3869.026
intellectual capital	118	intellectual capital	3704.719
knowledge acquisition	114	knowledge management (km)	3635.064
performance	106	semantic web	3409.226
semantic web	104	knowledge acquisition	3283.395
communities of practice	102	communities of practice	2992.594
social capital	100	performance	2686.415
management	98	project management	2570.325
project management	96	data mining	2569.916
case study	95	management	2496.138
organizational culture	95	social capital	2375.459
data mining	89	case study	2216.155
absorptive capacity	88	new product development	2071.063
new product development	87	organizational culture	1976.951
knowledge management (km)	86	internet	1751.147
competitive advantage	83	absorptive capacity	1730.339

#### 4.8. Intellectual Structure of Knowledge Management

Small first introduced the notion of co-citation and used the node-link network to visualize the co-citation relationship of 10 famous particle physics papers. Since then, many studies have created a visualization of co-citation relationships [39]. In a series of subsequent co-citation studies, White and Griffith documented the co-citation analysis principles and applications to map the advance of science, and identified the dynamic intellectual structure of science as a whole, or of particular domains [40]. Researchers later extended the unit of analysis from papers to authors, leading to author co-citation analysis (ACA) [55]. With many self-reflective co-citation research studies, two major types of co-citation analyses, Document Co-Citation Analysis (DCA) and Author Co-Citation Analysis (ACA) of Information Science, were used to visualize the intellectual structure of a whole domain, or of particular fields of study [40]. For this study, we used Document Co-citation Analysis (DCA) to explore the intellectual structure of knowledge management. Citespace, a tool for visualizing the intellectual structure, was used [56].

In this section, an individual network was derived from the 50 most cited articles published in the corresponding time period of two years, which ranging from 1974 to 2017. Then, these networks were merged into a network of 295 co-cited references that form an overview of the evolution of a scientific field over time (Figure 9). To improve the clarity of a visualized evolution network, we used a simplified network using pruning [31]. Here, a topology-based approach instead of a threshold-based approach was chosen for to more extensively consider intrinsic topological properties [56–58]. In this study, pathfinder network scaling instead of minimal spanning trees was used to preserve the chronological growth patterns in the co-citation networks. In Figure 9, the size of a node indicates the number of citations received by the associated reference. Each node is depicted with a series of citation tree-rings across the time frame slices. The structural properties of a node are displayed with a purple ring. The thickness of the purple ring indicates the degree of its betweenness centrality. Table 12 shows the most cited articles with detailed indicators.

From Table 12, the most cited papers by citation counts were during the period of 1995 to 2010. There are two main reasons for this phenomenon. The first is that modern knowledge management rapidly gained in popularity after 2000. The second is that the papers published in recent years need approximately 13–15 years to reach the highest number of citations.



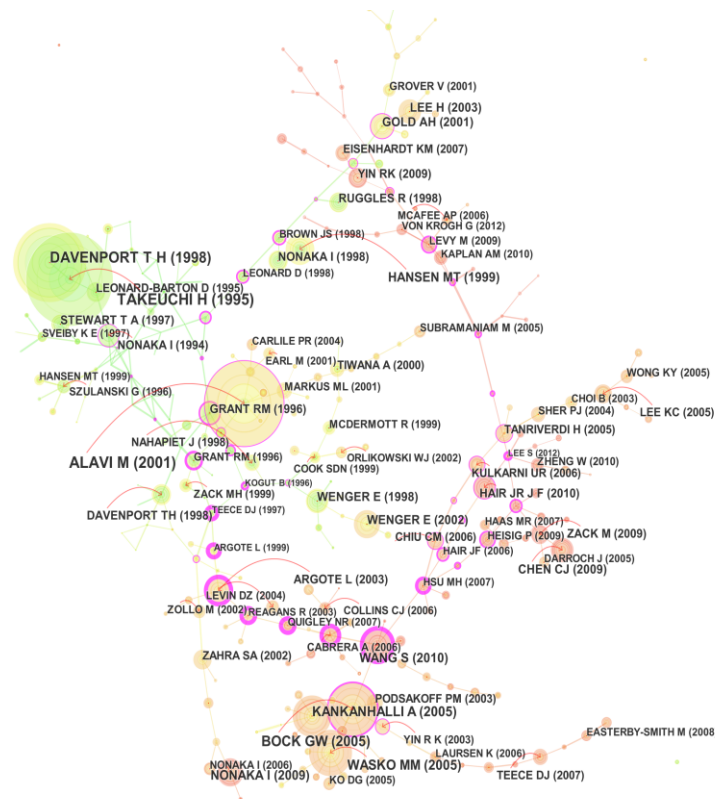


Figure 9. Citations in knowledge management research, shown as a Pathfinder network of cited references.

Table 12. The top 15 most cited papers by citation counts.

Rank	Citation Counts	First Author	Journal (Book)	Year
1	231	Nonaka	Oxford University Press	1995
2	212	Alavi	MIS Quarterly	2001
3	199	Davenport	Harvard Business School Press	1998
4	133	Bock	MIS Quarterly	2005
5	118	Wasko	MIS Quarterly	2005
6	109	Kankanhalli	MIS Quarterly	2005
7	80	Hansen	Harvard Business Review	1999
8	77	Wang	Human Resource Management Review	2010
9	77	Nonaka	Organization Science	2009
10	76	Wenger	Harvard Business School Press	2002
11	70	Wenger	Systems Thinker	1998
12	67	Gold	Journal of Management Information Systems	2001
13	66	Lee	Journal of Management Information Systems	2003
14	65	Chen	Journal of Business Research	2009
15a	63	Argote	Management Science	2003
15b	63	Hair	Prentice-Hall	2010

To further investigate the features of the intellectual structure of KM research, we used cluster mapping of co-citation document networks to complete a visualization analysis of the evolution of the intellectual base in the KM field. Based on the co-citation document networks, we used Citespace to divide the co-citation network into a number of clusters of co-cited references. These references are tightly connected within the same clusters, but loosely connected between different clusters. Table 13 lists 15 major clusters by their size, that is, the number of members in each cluster. Clusters with fewer members tend to be less representative than larger clusters because small clusters are likely to be formed by the citing behavior of a small number of publications.

**Table 13.** Summary of the largest 15 KM clusters.

ID	Size	Silhouette	Label (TF*IDF)	Label (LLR)	Label (MI)	Mean Year
0	26	0.961	profitability	Asia; call center; case study; modularity; dynamic capability	knowledge acquisition; knowledge creation; knowledge sharing; knowledge transfer; barriers and facilitator	2009
1	20	0.974	profitability	knowledge management system; new product development; organizational knowledge management; corporate strategy; product development	quality; knowledge management system; dimension; customer orientation; information system	2000
2	20	0.991	social constructionist analysis; pseudo-knowledge sharing	technology mediated learning; knowledge sharing; identity; gender; enjoyment	service quality; strategy; model; satisfaction; performance; success	2004
3	18	0.961	empirical analysis	boundary spanning; ERP system; ERP usage; key user; information technology professional	innovation; thinking; managing knowledge; systems thinking; information	2011
4	18	0.975	information sharing; work groups	human resource management; innovation; ultra-peripheral region; manufacturing performance; knowledge management	human capital; human resource management; innovation; start up; human resource management	2007
5	18	0.936	business format; concept	knowledge organization; product development; creation theory; management; community	dynamic capability; process alignment; organizational learning culture; competitive advantage; information technology	2001
6	18	0.93	knowledge management tutorial; people	knowledge management; cognitive congruence; schema; relationship script; resource-based view	resource based view; competitive advantage; firm; epistemology; creativity	1999
7	18	0.93	knowledge management; knowledge assets	organizational impact of knowledge-based system; knowledge engineering; core competency; job quality; knowledge-based system	intellectual capital measurement; knowledge management; intangible asset cognition	1995
8	18	0.835	information technology management; successful knowledge management projects	strategic alliance; knowledge transfer; causal ambiguity; organizational learning; knowledge management	resource based view; competitive advantage; firm; epistemology; creativity	1995
9	17	0.919	biotechnology sector	transitive memory system; team performance; field study; group decision making; coordinating expertise	human capital; human resource management; innovation; start up; corporate	2002
10	15	0.8	information technology management; information technology	Socio technical system; organizational memory; firm; appropriation problem; technological change	management of technology; technological learning; knowledge management; knowledge transfer; strategy	1994
11	15	0.894	impact; innovation	information sharing/withholding; knowledge transfer; reference group; profession; science	knowledge market; dyadic knowledge; knowledge management; knowledge exchange; intangible knowledge	2000
12	14	0.953	social media research; influence	knowledge based view; information system; social software; open innovation; managing knowledge	knowledge acquisition; knowledge creation; knowledge sharing; knowledge transfer; barriers and facilitator	2010
13	13	0.954	fundamental issue; antecedents	information technology; organizational performance; business performance; competitive advantage; research proposition	dynamic capability; process alignment; organizational learning culture; competitive advantage; information technology	2005
14	10	0.949	learning processes; firm level perspective	organizational change; product development; model; transformation; technology	social interaction; organization; innovation performance; manufacturing firm	2006

Note: Clusters are referred to in terms of the labels selected by the TF\*IDF, LLR (log-likelihood ratio), and MI (mutual information) methods. In information retrieval, TF\*IDF, short for term frequency-inverse document frequency, is a numerical statistic that is intended to reflect how important a word is to a document in a collection or corpus, whereas those chosen by log-likelihood ratio(LLR) tests and mutual information(MI) tend to reflect a unique aspect of a cluster [44,59].

Cluster #0 was the largest clusters, containing 26 nodes, and the value of the silhouette is 0.961. As the cluster was the largest cluster in the literature co-citation network, the theme of this cluster was relatively fragmented. To obtain more information about Cluster #0, we used Carrot to explain Cluster #0 in more detail. Table 14 outlines Cluster #0 using the lingo algorithm.

**Table 14.** Details of the largest cluster (Cluster #0).


Cluster Details	Cited Articles (Ranked by Citations)			
	Frequency	First Author	Year	Title
	65	Chen	2009	Strategic human resource practices and innovation performance: the mediating role of knowledge management capacity
	63	Hair	2010	Multivariate data analysis: A global perspective
	55	Zack	2009	Knowledge management and organizational performance: an exploratory analysis
	43	Heisig	2009	Harmonisation of knowledge management—comparing 160 KM frameworks around the globe
	40	Zheng	2010	Linking organizational culture, structure, strategy, and organizational effectiveness: Mediating role of knowledge management
	38	Hair	2006	Multivariate data analysis: A global perspective
	36	Haas	2007	Different knowledge, different benefits: Toward a productivity perspective on knowledge sharing in organizations
	36	Hsu	2007	Knowledge sharing behavior in virtual communities: The relationship between trust, self-efficacy, and outcome expectations
	35	Darroch	2005	Knowledge management, innovation and firm performance
	33	He	2009	A comparison of purchase decision calculus between potential and repeat customers of an online store

Table 14 shows that the earliest article in Cluster #0, “Knowledge management, innovation and firm performance” [60], mainly described the relationship between knowledge management and firm performance, which was then followed by the studies of Hair [61] and Haas [62]. Ranked by cited frequency, the core members of Cluster #0 represent major milestones in relation to knowledge management in or across organizations, including knowledge performance, competency, knowledge for innovation, and knowledge sharing. The second largest clusters (#1 and #2) both have 20 members and silhouette values of 0.971 and 0.991, respectively. We also used Carrot to explain Cluster #1 in more detail (Table 15). Ranked by cited frequency, the core members of Cluster #1 represent major milestones in relation to knowledge value, including the basic theory of knowledge value for firms, knowledge assets, and knowledge value.

Table 16 details Cluster #2. From Table 16, the most active citation in the cluster was “Behavioral Intention Formation in Knowledge Sharing: Examining the Roles of Extrinsic Motivators, Social-Psychological Factors, and Organizational Climate”. The core members of Cluster #2 represent major milestones of knowledge management research from the psychological perspective.

We also sorted the citation curve that includes the betweenness centrality and burst. The betweenness centrality of a node in the network measures the importance of the position of the node in the network. Table 17 shows 10 essential references in the synthesized network with high centrality. These references are important in terms of how they connect individual nodes in the network, and how they connect aggregated groups of nodes, such as co-citation clusters. Four of these nodes are in Cluster #11 and Cluster #4. These works can be seen as landmark works in the context of our broadly defined area of management.

Table 15. Details of the second largest cluster (Cluster #1).

Cluster Details	Cited Articles (Ranked by Number of Citations)			
	Frequency	First Author	Year	Title
	80	Hansen	1999	What’s your strategy for managing knowledge?
	67	Gold	2001	Knowledge Management: An Organizational Capabilities Perspective
	66	Lee	2003	Market Process Reengineering through Electronic Market Systems: Opportunities and Challenges
	61	Nonaka	1998	The concept of ‘Ba’: building a foundation for knowledge creation.
	57	Ruggles	1998	The state of the notion: knowledge management in practice
	43	Lee	2001	Exploring mediation between environmental and structural attributes: the penetration of communication technologies in manufacturing organizations
	37	Brown	1998	Organizing Knowledge
	31	Liao	2003	Knowledge management technologies and applications-literature review from 1995 to 2002
	30	Dell	1998	If Only We Knew What We Know: Identification and Transfer of Internal Best Practices
	29	Becerra-Fernandez	2001	Organizational Knowledge Management: A Contingency Perspective

Table 16. Details of the second largest cluster (Cluster #2).

Cluster Details	Cited Articles (Ranked by Number of Citations)			
	Frequency	First Author	Year	Title
	133	Bock	2005	Behavioral intention formation in knowledge sharing: examining the roles of extrinsic motivators, social-psychological factors, and organizational climate
	118	Wasko	2005	Why should I share? Examining social capital and knowledge contribution in electronic net- works of practice
	109	KankanHalli	2005	Contributing knowledge to electronic knowledge repositories: an empirical investigation
	50	Podsakoff	2003	Common method biases in behavioral research: A critical review of the literature and recommended remedies
	44	Ko	2005	Antecedents of Knowledge Transfer from Consultants to Clients in Enterprise System Implementations
	34	Lin	2007	A stage model of knowledge management: An empirical investigation of process and effectiveness
	32	Garud	2005	Vicious and Virtuous Circles in the Management of Knowledge: The Case of Infosys Technologies
	29	Ardichvili	2003	Motivation and barriers to participation in virtual knowledge-sharing communities of practice
	28	Alavi	2005	An Empirical Examination of the Influence of Organizational Culture on Knowledge Management Practices
	28	Delone	2003	Information System Success: A Ten Years Update

Table 17. Betweenness centrality ranking of the citations.

Centrality	First Author	Year	Source	Cluster ID
0.91	Wang	2010	Human Resource Management Review	4
0.89	Teece	1997	Strategic Management Journal	11
0.84	Cabrera	2006	The International Journal of Human Resource Management	4
0.81	Argote	2003	Management Science	11
0.81	Reagans	2003	Administrative Science Quarterly	11
0.81	Argote	1999	Springer, Berlin	11
0.8	Quigley	2007	Organization Science	11

Table 17. Cont.

0.67	Hsu	2007	International Journal of Human-Computer Studies	0
0.48	Grant	1996	Organization Science	11
0.41	Lee	2012	Journal of Knowledge Management	0

A citation burst has two attributes: the intensity of the burst and the length of the burst status. Table 18 lists references with the strongest citation bursts across the entire dataset during the study period of 1974 to 2017. The first article with a strong citation burst is “Working Knowledge: How Organizations Manage What They Know” from Cluster #24. The second-ranked article is “Situated Learning: Legitimate Peripheral Participation” and “Multivariate Data Analysis” is ranked third.

Table 18. Top 15 references with strongest citation bursts.

Strength	Reference	Burst Start Year	Burst End Year
106.699	Spender, J.C.; 1996, Strategic Management Journal	1996	2003
78.583	Grant, R.M.; 1996, Strategic Management Journal	2005	2009
70.1433	Nonaka, I.; 1995, Oxford University Press	1999	2006
30.9065	Alavi, M.; 2001, MIS Quart	2010	2013
29.37	Davenport, T.H.; 1998, Harvard Business School Press	2013	2017
29.1145	Bock, G.W.; 2005, MIS Quart	2005	2002
26.2479	Wang, S.; 2010, Human Resource Management Review	2010	2013
25.7965	Nonaka, I.; 1994, Organization Science	2009	2013
25.3509	Wasko, M.M.; 2005, MIS Quart,	2005	2007
24.9287	Kankanhalli, A.; 2005, MIS Quart	2013	2017
24.7793	Hansen, M.T.; 1999, Harvard Business Review	2000	2006
23.7432	Hair, J.F., Jr.; 2010, Prentice-Hall	2010	2003
22.1144	Wenger, E.; 1998, Cambridge University Press	1998	2005
22.0813	Leonard-Barton, D.; 1995, Harvard Business School Press	2000	2006
21.9779	Stewart, T.A.; 1997, Crown Business	1997	2004

#### 4.9. Emerging Trends

The modularity of a network measures the degree to which nodes in the network can be divided into a number of groups, such that nodes within the same group are connected tighter than the nodes in different groups. The collective intellectual structure of the knowledge of a scientific field can be represented as associated networks of co-cited references. These networks evolve over time. Newly published articles may introduce profound structural variation or have little or no impact on the structure. Figure 10 shows the changes in the modularity of networks during the past 10 years. Each network was constructed based on a two-year sliding window. The number of publications per year increased considerably. The modularity dipped in 2012 and then returned to the previous level. Based on this observation, groundbreaking works plausibly appeared in 2012.

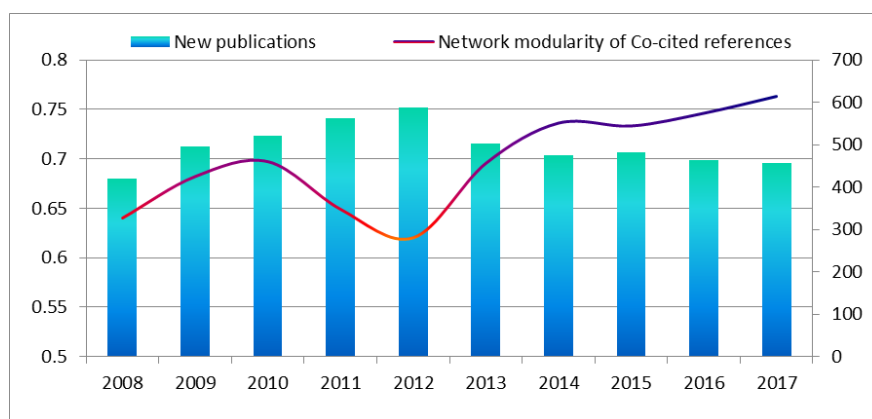


Figure 10. The modularity of the network.

Therefore, we specifically investigated potential emerging trends in 2012, and attempted to explain the significant decrease in the modularity of the network. If the publications in 2012 had a subsequent citation burst, then we expected that the publication played an important role in changing the overall intellectual structure. Ten publications in 2012 were found to have subsequent citation bursts (Table 19). Notably, from Table 19, Krogh [63] and Andreeva [64] were ranked first and second on the list. Both introduced research topics about new phenomena and the practice of knowledge management, and have current citation bursts after 2014. Other articles on the list address other research topics about SMEs management based on knowledge perspective, innovation, performance, and big data. These observations suggest that the modularity change in 2012 is an indication of an emerging trend in these areas.

**Table 19.** Articles published in 2012 with subsequent citation bursts in descending order of local citation counts.

Reference	Citations	Title	Source	Burst	Duration
Krogh	35	How does social software change knowledge management? Toward a strategic research agenda	Journal of Strategic Information Systems	15.8391	2014–2017
Andreeva	32	Does knowledge management really matter? Linking knowledge management practices competitiveness and economic performance	Journal of Knowledge Management	14.9919	2014–2017
Durst	30	Knowledge management in SMEs: a literature review	Journal of Knowledge Management	13.963	2014–2017
Chen	21	Business intelligence and analytics: from big data to big impact	MIS Quarterly	10.0375	2014–2017
Zhou	18	How knowledge affects radical innovation: Knowledge base, market knowledge acquisition, and internal knowledge sharing	Strategic Management Journal	8.4999	2014–2017
Guthrie	14	Reflections and projections: A decade of Intellectual Capital Accounting Research	British Accounting Review	7.8466	2015–2017
Lee	18	An integrated view of knowledge management for performance	Journal of Knowledge Management	7.8046	2014–2017
McAfee	12	Big data: the management revolution.	Harvard Business Review	6.7234	2015–2017
Podsakoff	14	Sources of method bias in social science research and recommendations on how to control it.	Annual Review of Psychology	6.457	2015–2017
Chan	11	An empirical investigation of factors affecting e-collaboration diffusion in SMEs	International Journal of Production Economics	5.6126	2014–2017

Four articles published in 2012 with subsequent citation bursts were review articles. Therefore, we deduced that review articles provide easier access to more citations in a short time period than other types of publications. This is consistent with previous studies [65].

## 5. Discussion and Conclusions

### 5.1. Discussion

Considering the limitations imposed by subjective judgment, chosen research scope in terms of time frame, analytical unit, and the lack of visualization perspective of prior publications, our paper comprehensively investigates global knowledge management from 1974 to 2017 to provide a quick overview of KM research. In this study, a coherent comprehensive bibliometric evaluation framework was used to investigate an emerging and promising cross-disciplinary domain, KM. We outlined the key development landscape of KM, including the growth pattern, international collaboration of countries, institutions, author distribution, intellectual structure, and emerging trends. The growth analysis showed that the scientific KM research is emerging as a cross-disciplinary domain among computer science, information science, management, and other research areas. The published KM papers significantly increased since 1991 in an S-shaped pattern, which is consistent with the analysis

performed by Styhre [23]. The subsequent country (territory) comparative analysis indicated the U.S., England, Taiwan, and China are the four largest contributors of the published KM literature. Compared with the findings of Gu, Japan and Canada were replaced by Taiwan and China [11]. The scientific research cooperation network analysis indicated that the U.S. is not only the original contributor, but also the largest international collaborating country. England is a close second with 246 international collaborated articles and China ranked third. National Cheng Kung University in Taiwan, Hong Kong Polytechnic University in China, and City University of Hong Kong (China) were the three largest contributors. We observed a decline in single-authored studies and relative stability in studies with two or three authors, and a clear growth trend in multi-authored articles, which is consistent with the analysis of single-authored and multi-authored KM studies [32].

The major publications for knowledge management research include *Journal of Knowledge Management*, *Knowledge Management Research & Practice*, and *Lecture Notes in Computer Science*. These findings agree with prior scientometric research that only highlighted the importance of *Journal of Knowledge Management* [11,23,32].

The visual co-word keyword analysis determined that Knowledge Management, Knowledge Sharing, Innovation, Ontology, KMs, Knowledge Management Systems, and Knowledge are consistent hotspots in KM research. The co-words network analysis showed that the central term Knowledge Management is closely related to the terms Ontology, Organizational Learning, Knowledge Sharing, and Information Technology. These combinations of related issues show that the KM research is focused on knowledge acquisition and sharing to improve knowledge management performance and organization dynamic capacity. This finding supports the conclusion on KM research in business literature as an independent stream, as stated by Akhavan et al. [32].

With the visual co-citation network analysis of references performed with CiteSpace and Carrot, we defined the intellectual structures of knowledge management, and found that four emerging research topics focus on new phenomena and the practice of knowledge management, SMEs management based on knowledge perspective, innovation and performance, and big data-enabled KM.

For new phenomena and the practice of knowledge management, rapid technological changes affect the information and communication technologies that are providing new data mining and predictive analytics solutions. Additionally, the rapid development of social networks, such as Facebook and Twitter [66,67], also influences knowledge management. So, given this context, we can formulate the first research questions (RQ):

**RQ1:** *How do different emerging technologies change knowledge management?*

Secondly, for SMEs management based on the knowledge perspective, some studies have emphasized the importance of the role of KM in small- and medium-sized enterprises. A consensus conclusion shows that SMEs are starting to make focus on KM practices. However, little research has been completed about the KM of SMEs. Most notably, few empirical studies have been performed on SMEs [6,7,15]. Some academics have focused on SMEs and discussed the KM of SMEs, but some important research issues have been neglected. Given this context, we formulated the next two research questions:

**RQ2:** *What are the critical difference between SMEs KM and large companies?*

**RQ3:** *How should the effective development of SMEs KM be promoted?*

Third, innovation and performance based on KM or a KM-based viewpoint is a hot topic in the KM domain. Many studies discussed the relationship between knowledge management and innovation and performance. However, its mechanism is still unclear [21,50]. In additional, most studies focused on large companies. SMEs and startup company innovation and performance research based on the KM perspective should be highlighted. It was then possible to formulate the fourth research question:

**RQ4:** *How to promote the mechanism research among knowledge management, innovation and performance, not only in large companies but also in SMEs and startups?*

Fourth is big data-enabled KM. The rapid development of big data has created many challenges for KM. Big data can be considered as a knowledge asset, and thus the field of knowledge management gained new momentum with the introduction of big data analytics for knowledge creation [14]. So, we formulated the fifth research question:

**RQ5:** *How should big data be managed to address the challenges of KM caused by big data?*

For additional studies, we examined the papers' abstracts, and found that most of the literatures on knowledge transfer and knowledge sharing have introduced various measures to promote knowledge sharing, but few were successful in practice. Therefore, we must strengthen the transfer between KM academic research and KM practice. From this, we propose the next research question:

**RQ6:** *How can the communication between KM academic research and KM practice be strengthened?*

Another research gap was also observed. Previous studies usually focused on the research of knowledge sharing, transfer, and creation, and lacked research on KM failures, such as knowledge hiding and knowledge hoarding [68,69]. Some scholars have begun to focus on this kind of behavior. However, the critical factors leading to these behaviors are still unclear. Therefore, determining the critical factors is an important task for future knowledge management research about negative behavior. From this, we propose the last two research questions:

**RQ7:** *What are the main behaviors leading to KM failure?*

**RQ8:** *What are the critical factors leading to KM failure?*

## 5.2. Implications for Academics and Practitioners

Based on the above proposed research gaps and questions, our results provide guidance and draw implications for future research and practices. For academics, these implications may offer some possible areas or interesting questions for the development of KM.

On the other hand, the findings above have implications for both academics and practitioners. Firstly, the research presented in this paper particularly benefits academics, researchers, and research students wanting to quickly obtain a visualization overview of knowledge management research.

The research topic analysis, which was based on co-keywords, can also be useful for curriculum designing. For example, considering their importance in KM research, knowledge sharing, knowledge and innovation, ontology, knowledge management systems, knowledge transfer, organizational learning, and knowledge creation should be included in curricula for graduate and undergraduate programs about KM.

Based on our findings about the emerging trends in KM, researchers can better understand the development of KM and quickly and efficiently determine valuable research topics for the future. New phenomena and the practice of knowledge management, SMEs management based on knowledge perspective, innovation and performance, and big data-enabled KM are emerging research topics, which should receive more attention from researchers in this field.

Moreover, by identifying the current KM research status, this study provides an opportunity for practitioners and academics to check the extent to which academic research is keeping pace with the KM issues confronted by managers. This may become a starting point for communication between academics and practitioners.

## 5.3. Limitations and Direction for Future Research

The results from our study should be interpreted in light of several potential limitations due to the research design and the intrinsic drawbacks of bibliometric methods. First, by focusing on two research objectives, we used 7628 original research articles retrieved from the Web of Science core collection for bibliometric analyses, which may be criticized. Although the Web of Science core collection is an effective and good data source for bibliometric analysis, some limitations exist if it is



used as a unique database. Future research can address this limitation by expanding the data sources used and merging the data from various databases, like Scopus, Emerging, and PubMed.

Secondly, we mainly used the frequency indicator to outline the present KM situation because frequency is the most commonly used indicator in bibliometric analyses. However, some valuable units may be ignored. Although betweenness centrality and degree centrality were also used to improve our analysis of international collaboration of among countries, distribution and collaboration of institution, and co-word keyword networks, future research is still needed to integrate various indicators.

Lastly, in the intellectual structure analysis section, our study followed the general paradigm of bibliometric research, and did not analyze the epistemology and ontology problems in the articles, which may cause some misunderstanding for readers. This is due to the limited functions of the intrinsic drawbacks of bibliometric analyses. However, we believe that considering the problems about epistemology and ontology in the articles is important and valuable. Therefore, we hope to address up this gap by introducing more methods, like rounded theory method and systematic reviews, in future research.

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