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# Visualizing the Academic Discipline of Knowledge Management

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Received: 29 December 2017; Accepted: 18 February 2018; Published: 2 March 2018

**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 lacing. 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 indicters 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.

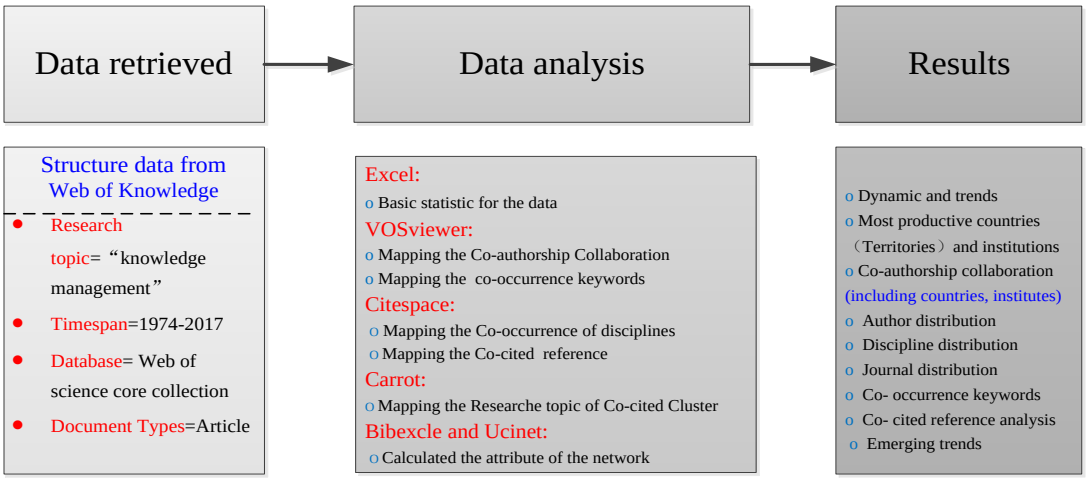


**Figure 1.** Research methodology.

## 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.

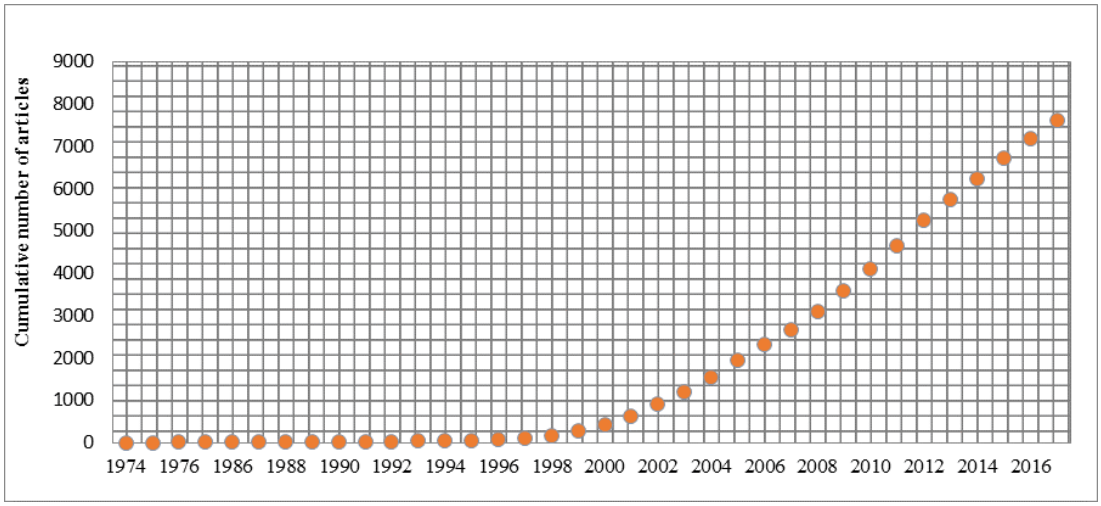


**Figure 2.** Cumulative growth in knowledge management publications, 1974–2017.


**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 |

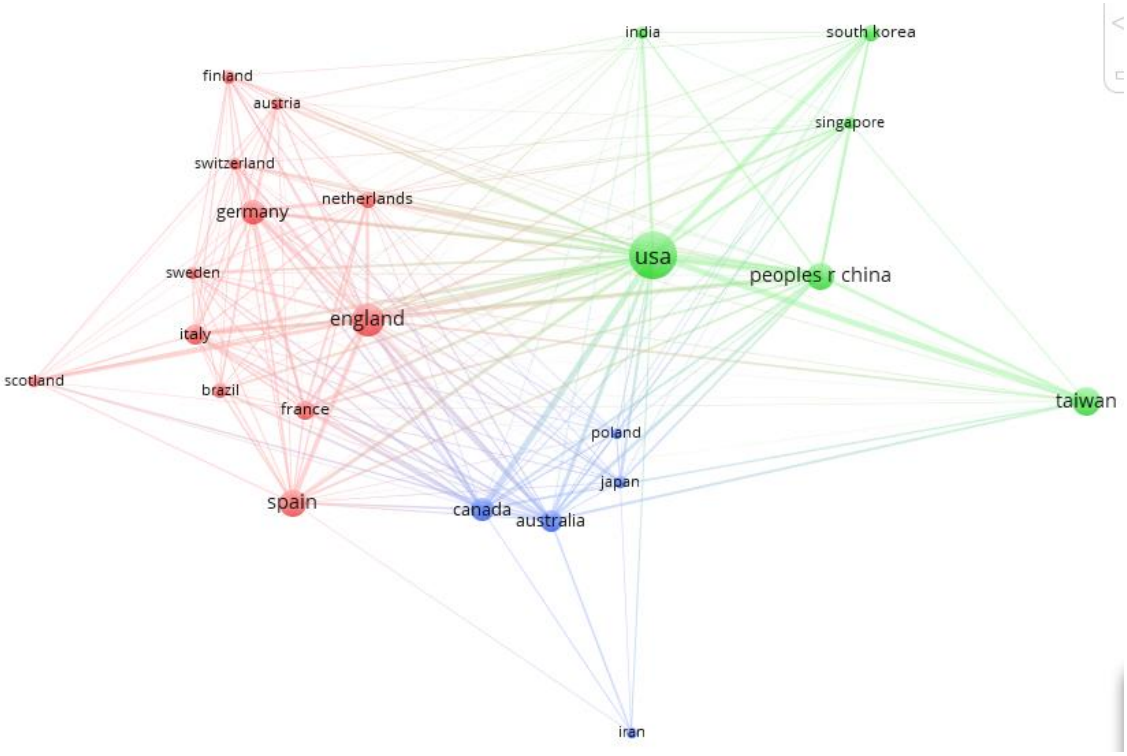


**Figure 4.** International collaboration network of the top 23 countries in KM research. The network was created using VOSviewer. The thickness of the linking lines between two countries is directly proportional to their collaboration frequency.

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.

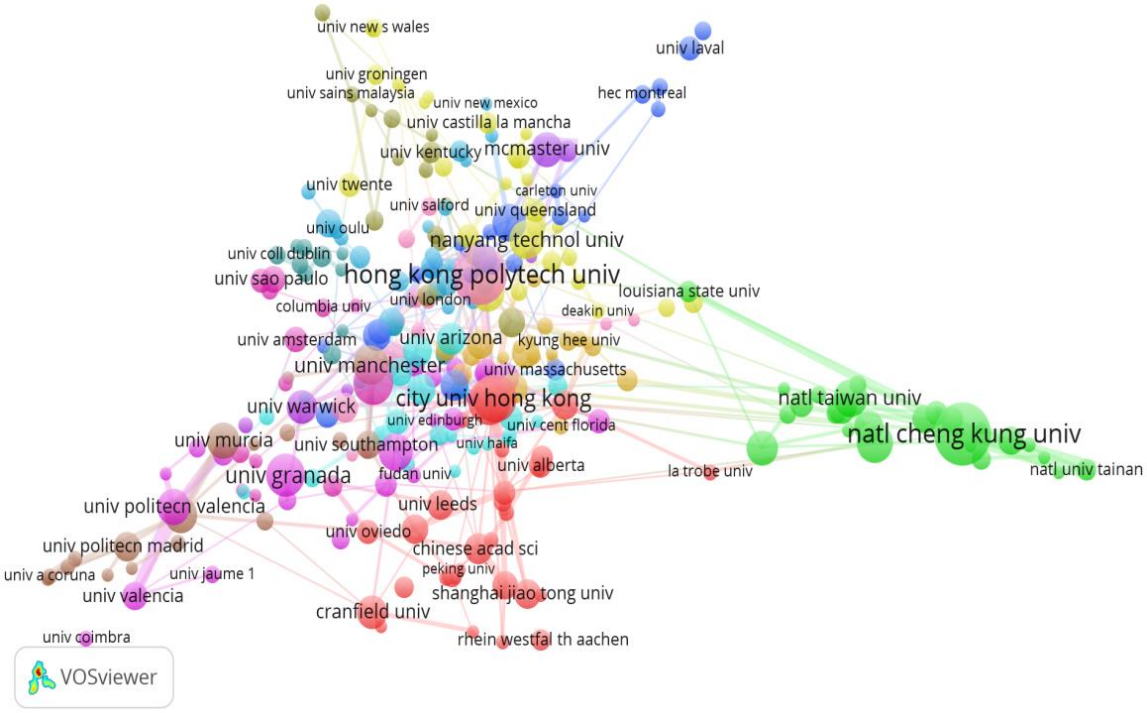


**Figure 5.** Collaboration network for institutions with more than two articles published contains 791 nodes.

**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.

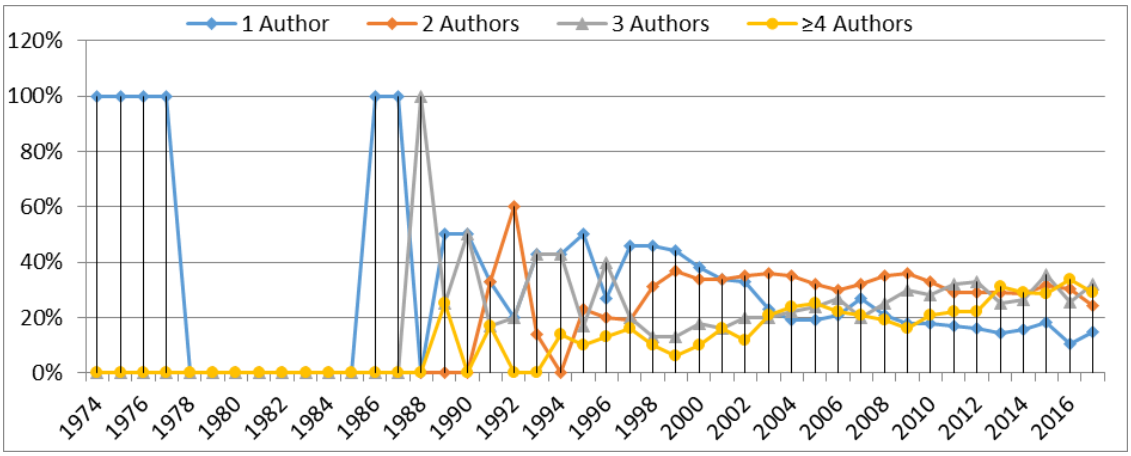


**Figure 6.** The percentage of articles with different numbers authors by year.

### *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% |

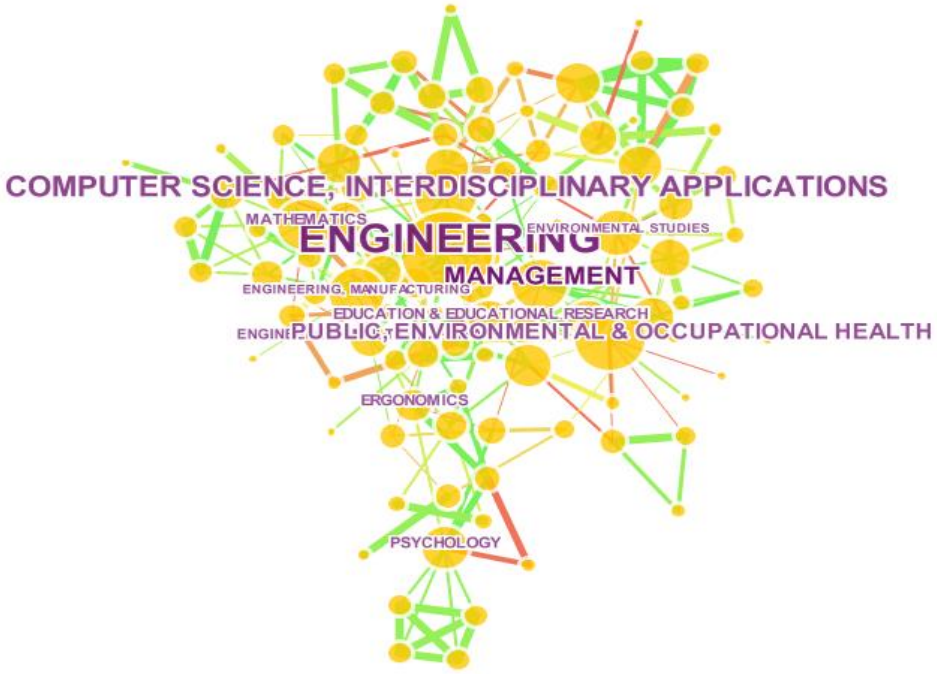


**Figure 7.** Disciplines involved in KM.

**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).

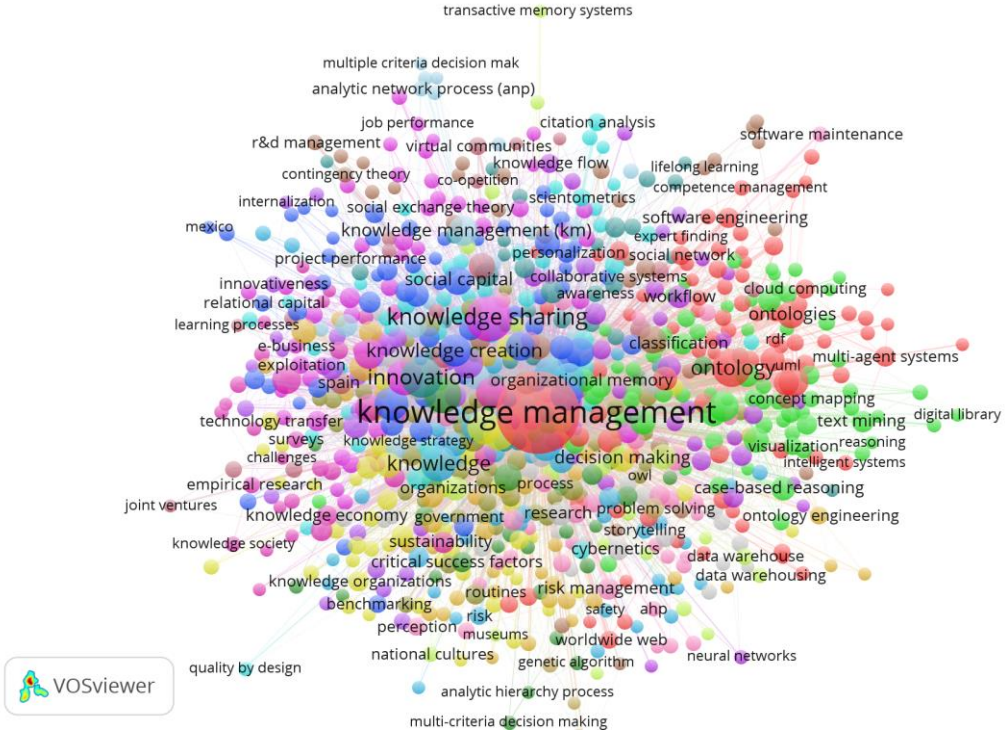


**Figure 8.** The co-words network of author keywords.

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.

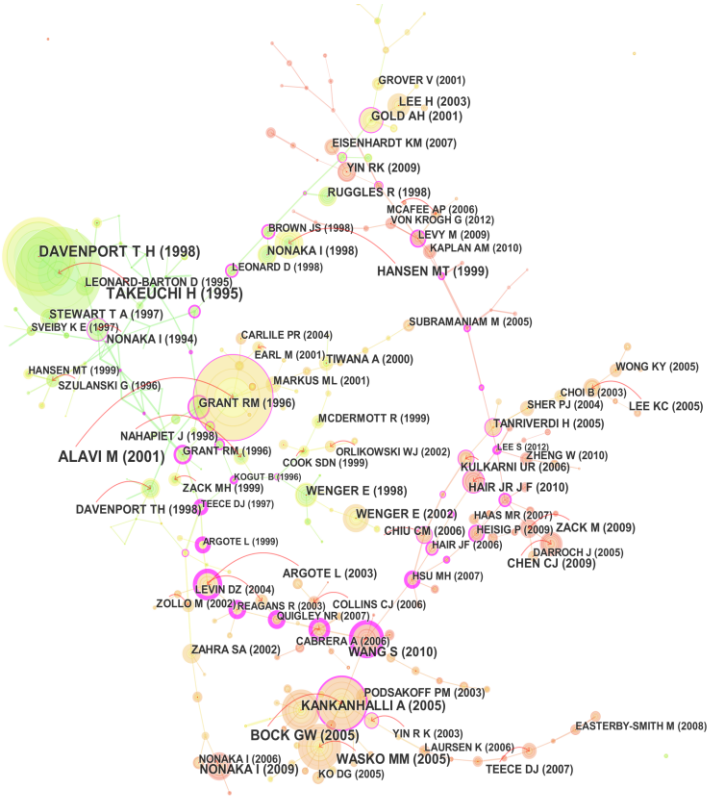


**Figure 9.** Citations in knowledge management research, shown as a Pathfinder network of cited references.

**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 assert 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.

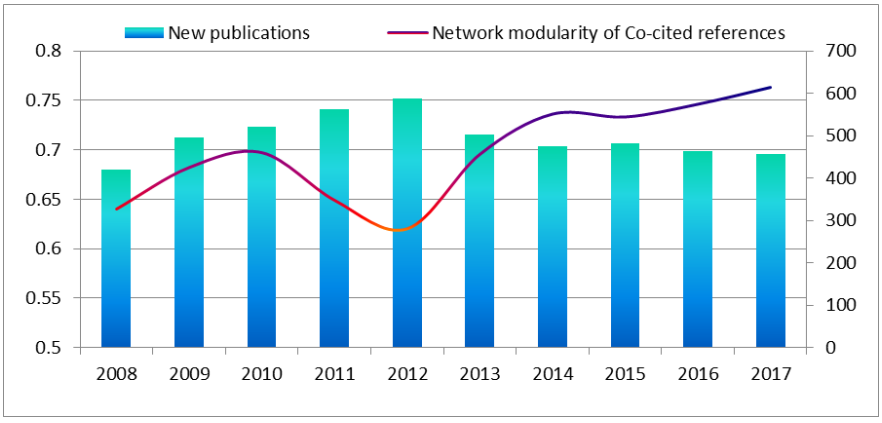


**Figure 10.** The modularity of the network.

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 |
| Guthire | 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.

**Acknowledgments:** This research is funded by National Natural Science Foundation of China (71372085). The authors are very grateful for the valuable comments and suggestions of the anonymous reviewers, which significantly improved the article.

**Author Contributions:** Peng Wang designed this research and collected the data set for the experiment. Fang-Wei Zhu analyzed the data to show the validity of this paper. Hao-Yang Song, Jian-Hua Hou and Jin-Lan Zhang wrote the paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

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