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Bilgi Yönetiminde Büyük Verinin Evrimi: Bibliyometrik Bir Analiz

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Research Article

The Evolution of Big Data in Knowledge Management: A Bibliometric Analysis

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Abstract

Recently, the close relationship between big data and knowledge management has become one of the important agendas of businesses. The aim of this study is to systematize the literature on big data and knowledge management from a bibliometric perspective and to create a general framework for the past, present and future of the field. The present study examined 622 papers acquired from the Clarivate Analytics Web of Science (WoS) Core Collection database between 2013 and 2020. The results showed that the annual growth rate of the relevant field was found to be 42.9% indicating a higher popularity among researchers. China and USA are home to the most productive authors and institutions in the field. Also, country collaboration network, institutional co-authorship network, co-word network and co-citation network are given to present the intellectual structure of the field. This study is useful to understand leading trends in the field in terms of the most influential authors, institutions and countries, the most productive journals, the most frequent keywords, the collaboration networks and the co-citation networks. To the best of researchers' knowledge, this study is the first bibliometric examination attempt to understand the flow at the intersection of big data and knowledge management over time.

Keywords: *Knowledge management, bibliometric analysis, big data, science mapping, big data management.*

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Araştırma Makalesi

Bilgi Yönetiminde Büyük Verinin Evrimi: Bibliyometrik Bir Analiz

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Öz

Son zamanlarda büyük veri ve bilgi yönetimi arasındaki yakın ilişki, işletmelerin önemli gündemlerinden biri haline gelmiştir. Bu makalenin amacı, büyük veri ve bilgi yönetimi alanyazınını bibliyometrik bir bakış açısıyla inceleyerek alanın dünü, bugünü ve geleceği için genel bir çerçeve oluşturmaktır. Çalışmada 2013-2020 yılları arasında Clarivate Analytics Web of Science (WoS) Core Collection veri tabanından elde edilen 622 makale incelenmiştir. Analiz sonuçları, ilgili alanın yıllık büyüme oranının %42,9 olduğunu göstermekte ve bu da alanın araştırmacılar arasında yüksek bir popülerliğe sahip olduğuna işaret etmektedir. Çin ve ABD, bu alandaki en üretken yazarlara ve kurumlara ev sahipliği yapmaktadır. Ayrıca, alanın entelektüel yapısını ortaya koymak için ülke işbirliği ağı, kurumsal ortak yazarlık ağı, ortak kelime ağı ve ortak alıntı ağı verilmiştir. Bu çalışmanın, en etkili yazarlar, kurumlar ve ülkeler, en üretken dergiler, en sık kullanılan anahtar kelimeler, işbirliği ağları ve ortak atıf ağları açısından alandaki önde gelen eğilimleri anlamak için araştırmacılara yol gösterici olacağı düşünülmektedir. Araştırmacıların bilgisi dâhilinde, bu çalışma zaman içinde büyük veri ve bilgi yönetiminin kesişimini ve ilişkisini anlamaya yönelik yapılan ilk bibliyometrik inceleme girişimidir.

Anahtar sözcükler: *Bilgi yönetimi, bibliyometrik analiz, büyük veri, bilimsel haritalama, büyük veri yönetimi.*

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Introduction

Big data is a constantly developing concept which lacks a generally approved definition, but gains new characteristics with almost every day, and enters all areas of business and social life. In the most general terms, big data refers to data sets in structured, semi-structured or unstructured format (Gahi et al., 2016; Kaur & Sood, 2017) that may go beyond the processing capacity of daily database systems (Dumbill, 2013), and are too complex to be analysed and processed simply (Fisher et al., 2012).

McAfee and Brynjolfsson (2012), identified that the three most used features to describe big data are the *volume, variety,* and *velocity* of data. These three features form the basic framework used in big data definitions. As time progresses, however, different features to express big data have started to appear owing to computers and new software with high capacity to process big data. Later studies presented the dimensions of the *business value* of big data (Dijks, 2011; Gogia, 2012) and *veracity* (White, 2012). Recently, thanks to the increasing knowledge about big data and to developing artificial intelligence technologies, large data sets have been better processed and visualization of data has become possible. In this context, Seddon and Currie (2017) pointed out seven basic features of big data by adding *variability* and *visualization* dimensions to big data features.

Big data is widely used to assist operational level company activities like purchasing, producing, warehouse management, and logistics for the purpose of increasing the rationality, efficiency, and pace of routine and repetitive activities (Power, 2015). The capacity of a company to collect and analyse big data depends on the presence of a number of basic sources within its organization (Mikalef et al., 2017). As a matter of fact, with such sources, businesses aim to be able to better manage knowledge and performance by building their capacity in terms of big data analytics. In this context, Gupta and George (2016) mentioned that companies need some human skills with tangible and intangible in order to create big data analytics capabilities. Tangible resources are associated with data integration techniques inside and outside the enterprise, data storage, data processing, data analysis and data visualization technologies, and big data investments, while intangible resources are associated with data-based corporate culture and data-based decision-making besides intense learning, gaining and sharing knowledge, and interpreting and applying the acquired knowledge based on big data (Gupta & George, 2016). Human skills, on the other hand, refer to the technical, managerial and relational skills of data analysts and other employees required to perform big data analytics effectively (Gupta & George, 2016; Wamba et al., 2017). As a consequence of big data analytics, businesses discover embedded information in data stacks and generate new knowledge that adds value to businesses from among meaningless data (Khan & Vorley, 2017).

Knowledge management has become an integral element of today's businesses. Drawing upon knowledge, businesses can better manage their performance and actions (Alavi & Leidner, 2001). Knowledge management enables businesses to acquire new knowledge, transform it into more usable and accessible formats, and put it into practice across the organization (Gasik, 2011). In such manner, their market share can grow, customer network can expand, customer satisfaction can increase, productivity and efficiency can be improved, potential to innovate can rise; and consequently, they may end up experiencing higher financial success (Ferraris et al., 2018).

From the past to the present, many studies have been conducted on the contribution of knowledge to the economic growth and productivity enhancements of businesses (Gaviria-Marin et al., 2019). Knowledge management is a relatively new discipline that is generally regarded as an effective resource for determining and developing the strategic orientation of a company's competitive advantages, and in this respect, is of great interest for researchers and academics (Serenko et al., 2011). Although current knowledge management theories began to emerge in the early 1960s, the value proposition of knowledge management began to appear in the 1990s in line with the development of the information age, when knowledge was recognized as crucial to firm innovativeness and competitive advantage (Nonaka & Takeuchi, 1995).

Business organizations have to develop and update themselves in order to remain competitive by adapting to rapidly changing conditions and new business environments. In our age of big data, it is entirely possible for businesses to reach valuable knowledge to take advantage of during decision-making through the effective analysis of data obtained from various sources (Sumbal et al., 2017). Obtaining new knowledge by analysing large data sets has become the new focus of businesses. Concepts such as business analytics and business intelligence are directly related to increasing business performance with the knowledge to be obtained by analysing structured or unstructured data stacks with such methods as data mining, deep learning, statistical analysis, machine learning, or natural language processing (McAfee & Brynjolfsson, 2012). For example, e-commerce sites like Amazon.com and Alibaba.com are customer-oriented, and thus, constantly optimizing themselves. These websites reorganize their processes and systems by simultaneously analysing the data they obtain from customers, records of transactions, social media, and other web-based sources via artificial intelligence-aided methods like machine learning, in a way that distinguishes trends and personal preferences (Davenport et al., 2012). Drawing upon big data analytics, these companies can manage real-time knowledge and obtain a competitive advantage over their opponents.

According to researchers, cyclical structures in knowledge management may already have become obsolete and outdated as a consequence of big data (Tian, 2017). With the advent of big data, the traditional depiction of the relationship between data,

information and knowledge has lost its importance since data has now become the main element of activities and decision-making mechanisms in all businesses and economies (Batra, 2014). Decision-making is not the result of long hypothesis testing process from now on, but rather the result of predictive modelling based on big data. Now organizations, individuals, and societies learn from data to predict the future and make more accurate decisions. Thanks to the information technology-oriented meaning-making process known as datafication, new data is created at multiple points and converted into a digitized format for analysis, thus enabling planning and forecasting (Mayer-Schönberger & Cukier, 2013). In such estimations, different relationships are attempted to be found from among data flows, and the difference between information and knowledge produced from data becomes insignificant, indicating that knowledge management is likely to develop very differently in the future (Tian, 2017).

With all these definitions, big data is a controversial field on which there is no consensus (Zhan & Widén, 2019). We anticipate that this consensus will be formed through separate analyses of concepts directly related to big data, which is one of the main motives of our research.

This study conducted a bibliometric analysis of the studies examining the relationship between big data and knowledge management from various aspects by drawing on data from studies published on Clarivate Analytics Web of Science (WoS) between 2013 and 2020. The reason why 2013 was chosen as the starting year is that studies examining the link between big data and knowledge management started to attract attention mainly after this year. In the years up to this year, there were one or two publications, or in some years there were no publications. Bibliometric analysis presents the annual article increase, productive authors in the field and their influence on the field, co-authorship networks and country collaboration networks, analysis of keywords in studies and their co-word networks, and finally, citation analysis. Through bibliometric analysis, this study aimed to present the development and change of big data use in the field of knowledge management through the years by specifying the research areas' clusters in respect of the author keywords, journal networks, and country collaboration networks. In addition, based on the results of the analysis, inferences were made about what the current fields of study could be for researchers and how the fields could alter in the future.

Purpose of Research and Research Questions

This study aimed to make a bibliometric review of the studies in the field of "big data and knowledge management" between 2013 and 2020. Bibliometric analysis can be conducted using various software packages. In this study, Aria and Cuccurullo's (2017) the *bibliometrix* package for use in the R statistical software program was used. This program is highly preferred by researchers in bibliometric analyses, due to its open

source codes. In this way, the data taken from WoS were easily analysed. In addition, VOSviewer program was used to visualize bibliometric networks. Especially through VOSviewer, networks and collaborations in bibliometric data sets were presented in a visually easy-to-understand and professional view. In the current study, journals and articles included in the Clarivate Analytics WoS database were selected for the investigation of research field. The reason why 2013-2020 was chosen as the time frame is that big data studies in the field of knowledge management began to take shape in 2013 and later. The number of studies using big data in the field of knowledge management on a global scale, as well as their characteristics, development in the field and suggestions for relevant future studies were presented with bibliometric analyses. Specifically, this study sought to answer the research questions below:

- How has the use of big data developed in knowledge management field over time?
- Which authors highly influenced the research field?
- Which journals had the highest impact on the research field?
- Which countries are the most productive in this research field?
- How is the collaboration between countries?
- How do the keyword structure and keyword clusters in the research field take shape?
- How the intellectual structure of this field is shaped referring to the co-citation networks of journals and articles?

This study provides a subjective and qualitative evaluation of the literature by examining the studies on big data in the field of knowledge management from a quantitative perspective. It also offers a comprehensive picture of the available big data studies conducted in relation to knowledge management and examines emerging trends in the field.

Theoretical Framework

Knowledge Management

Knowledge management and intellectual capital, which are regarded as sister disciplines, consist of the arguments indicating that it is possible to exhibit activities that will add value to organizations through better use of knowledge assets (Rothberg & Erickson, 2017). The idea that knowledge-based assets are a key source of competitive advantage for businesses has appeared together with the development of the resource-based approach (Wernerfelt, 1984). Provided that the knowledge and experience of employees are used more efficiently, a unique and sustainable organizational resource

is likely to be constituted to achieve distinctness in the field. Since the concept of knowledge started to attract the attention of researchers and organizations, an intense effort has been made to define it. The most well-known one among a number of definitions is related to the hierarchy defined as data, information, knowledge, and it was developed by Ackoff (1989). This hierarchy and other definitions have been inspiring for the schemes of information systems and definitions of knowledge management. According to this hierarchy, *data* represents our observations, *information* is organized or contextualized data, *knowledge* is data based on our experience or reactions to events, and *wisdom* comes from insights (Rowley, 2007). Nowadays, with the increasing interest of businesses in big data, the hierarchy of data, information, knowledge, and wisdom developed by Ackoff (1989) needs to be redesigned with a transformation from data/information to explicit knowledge, as well as from tacit knowledge to insight/intuition (Rothberg & Erickson, 2017).

Knowledge management is a company's process of acquiring new knowledge, giving it a certain format, using it, and putting it into practice across the organization (Gasik, 2011). Thanks to the knowledge management processes, knowledge is engaged in an organization, stored, and transferred whenever necessary. In this process, big data analytics is of great significance (Davenport et al., 2012). When knowledge is considered in relation to organizations, explicit and implicit knowledge comes to mind (Nonaka & Takeuchi, 1995). Explicit knowledge can be documented, easily transferred from one place to another, and embedded in standard procedures (Kogut & Zander, 1992; Martin & Salomon, 2003). Conversely, implicit knowledge refers to tacitly implied and uncoded knowledge. In this way, it is difficult to access knowledge as a text, varying according to certain conditions and circumstances (Crane & Bontis, 2014; Nonaka, 1994). Nonaka and Takeuchi (1995) indicated that explicit and implicit knowledge are complementary to each other and can be transformed from one form to another in some organizations. Transforming knowledge between forms is not a simple task since businesses must make systematic efforts to obtain the benefits of implicit knowledge. Big data analytics is vital in capturing, acquiring and sharing explicit information within data stacks through the insight of implicit knowledge (Davenport et al., 2012; Scarbrough & Swan, 2001).

Knowledge management has been handled from different perspectives in a variety of studies and used as an umbrella term for concepts like knowledge creation, mapping and/or indexing knowledge, transferring knowledge, storing and distributing knowledge, knowledge valuation and knowledge metrics as well as knowledge sharing (du Plessis, 2007). Today, the most critical success factor for companies is the need to transform data into knowledge for the purpose of decision making. In line with this need, various knowledge management approaches, eras, stages, and generations have emerged so far (Firestone, 2001; Firestone & McElroy, 2003; Wiig, 2004). All of such aspects demonstrate companies' need to accumulate, create, organize, spread, manage,

and be accountable for intangible resources that serve to explain how businesses derive knowledge from their insights (Bontis, 2001; Stewart, 2010). In this way, various and sundry knowledge management frameworks, models, knowledge structures, management strategies, processes, and knowledge management cultures began to emerge in organizations, some of which are intensely dependent on technology usage and some less (Alavi et al., 2005). The nature and role of knowledge, which differs in context, need, purpose and relevance according to the effect of technology, has become vital for companies and researchers.

Widespread debates have long been going on that knowledge is an important source of advantage for all economies and organizations. According to Peter Drucker (1995), knowledge is the only important economic resource. For this reason, the processes of creating, accumulating, disseminating and applying knowledge need to be managed effectively for the benefit of all individuals, organizations and societies. In this context, various knowledge management frameworks have emerged over time. Some of these are descriptive, explaining basic knowledge management phenomena, while others are predictive frameworks that set methodologies for the administration of knowledge management (Tian, 2017). The content of such knowledge management structures includes the most important knowledge management processes such as the knowledge creation or accumulation, in addition to organization, transfer, share, and the use of knowledge, and their sub-dimensions. For example, knowledge management processes of Bhatt (2001) include the processes of creating, verifying, formatting, distributing and putting knowledge into practice, respectively.

The Role of Big Data in Knowledge Management

The most criticized aspect of knowledge management structures that have developed over time is that they fail to give enough space to the source of knowledge and their mutual relations (Holsapple & Joshi, 2002). These structures are generally cyclical and the processes depicted are sequential, yet non-linear. In this regard, knowledge management structures can neither start nor stop in real sense, but can work in parallel to each other (Wiig, 2004). Organizations have long been familiar with knowledge management and its various forms. As time passes, however, they face various challenges in knowledge management and need new strategies to overcome them. One of such strategies is the use of big data. Associating big data with organizational knowledge management is among the most crucial agendas of organizations, and businesses invest in big data with the desire to produce new knowledge that adds value to businesses and gain competitive advantage, accordingly (Sumbal et al., 2017).

The link between big data and knowledge management is fostered by the knowledge-related approach (Davenport et al., 2012; Grant, 1996). According to the knowledge-based approach, knowledge is the main spring of competitive advantage also, there is a mutual relation between knowledge and its management (Grant, 1996).

Knowledge forms the basis of knowledge management, and decision-making efficiency is increased by extracting explicit and implicit information from data stacks through big data analytics (Beyer & Laney, 2012; Grant, 1996).

In big data and knowledge management, the goal is often the same: to make more accurate decisions by drawing on knowledge. The difference is the way they pursue this goal. Large data sets are obtained from a wide variety of resources in structured, semi-structured or unstructured formats, and are transformed into a meaningful piece of knowledge describing trends and relationships in big data sets through various analytical methods. When such information is supported and interpreted by business analytics tools and analysed by data analysts, value-creating and actionable knowledge that forms the core of knowledge management emerges (Sumbal et al., 2017). This relationship shows the strong link between big data and knowledge management.

One of the most challenging issues for organizations in the field of knowledge management is to reuse knowledge by transforming it from one form into another. In order to overcome this, organizations need to take consistent and solid steps to achieve the determined goals by using implicit knowledge effectively (Thomas & Chopra, 2020). These steps are likely to engender a contextual relationship between knowledge management and big data analytics (Davenport & Patil, 2012; Khan & Vorley, 2017). Khan and Vorley (2017) suggested that big data analytics has an eye-opening role in capturing, accumulating, and sharing open data within datasets and pointed out how these can be interpreted through implicit intuitions. In this context, big data and knowledge management have similar aims such as disseminating knowledge and producing definite results for the use of organizations.

Big data benefits the field of knowledge management at an exponential rate, and this will become a necessity for the future of knowledge management (Thomas & Chopra, 2020). The collective knowledge of organizations should be digitized and prioritized by taking the current demands of the markets into consideration. Knowledge management should be innovative to meet organizations' changing needs of knowledge. Data-driven insights to help organizations make decisions are likely to boost the success of knowledge management. Integrating knowledge management with big data technology enables the extraction of meaningful and valuable information from data stacks in such a way that forms the basis of knowledge management.

Knowledge is considered as the basic element of revealing any theory on big data (Pauleen & Wang, 2017). Without big data and analytical information, the desired results cannot be achieved since information is the main element of the development and real potential of big data. How big data will be collected and analysed, and how the new information will be used depends on human knowledge. Knowledge, therefore, plays a critical role on how big data will be put into practice, and how the end results will be interpreted and used.

Research Methodology

Bibliometric analysis is a method that examines the qualitative and quantitative changes that occur under a scientific research title within certain periods by making use of various statistical methods, and reveals the profile of the publications in this research field, as well as providing information about the possible field-related future trends (De Bakker et al., 2005). Bibliometric analysis includes two basic procedures, namely, performance analysis and science mapping, in order to explore a research area (Zupic & Čater, 2015). Performance analysis aims to evaluate scientific grouping actors (like countries, universities or departments, and researchers) and the influence of their activities, based upon bibliographic data. Scientific mapping, on the other hand, aims to demonstrate the structural and dynamic aspects of scientific fields, delimit a field of research, in addition to measuring and visualizing sub-domains identified through co-word analysis or co-citation analysis of documents (López-Herrera et al., 2012). In bibliometric studies, the characteristics of a particular field of research are examined under various headings by using scientific mapping techniques. While examining the progress and development in a study field in bibliometric analyses, various sub-titles are used such as citation analysis, author relationship analysis, keyword analyses, and cross-country collaborations (Koseoglu et al., 2016; McBurney & Novak, 2002). In this way, researchers can objectively contribute to a better understanding of the specified fields of study and to determine clearer publication policies by conducting a wider literature review (Zupic & Čater, 2015).

Defining Keywords and Data Collection

Despite the availability of various article databases in the international arena, the present study drew upon the records obtained from the WoS database. WoS is an internationally recognized digital platform with high quality standards, offering publications and journals in a wide variety of categories. Most of the researchers who conduct bibliometric studies prefer the WoS database due to its suitability for bibliometric studies, since the abstracts, reference lists, number of citations, author lists, institution lists, country productions, and journal impact factor in the data set(Carvalho et al., 2013).

In order to extract data from the WoS database, researchers must first determine the keywords to be used. The present study investigated the previously used concepts in the literature in the field of knowledge management while choosing keywords. Among the most frequent concepts in the literature are knowledge creation, knowledge transfer, knowledge use, knowledge integration, knowledge dissemination, knowledge application, and knowledge sharing (Alavi & Leidner, 2001; Choi et al., 2010; Gaviria-Marin et al., 2019; Tiwana, 1999; C.-C. Wang et al., 2017). Referring to these keywords, we created a search function as below:

TS=((“big data*”) AND (“knowledge manage*” OR “knowledge acquisiti*” OR “knowledge discover*” OR “knowledge creat*” OR “knowledge shar*” OR “knowledge integra*” OR “knowledge diffus*” OR “knowledge adopt*” OR “knowledge stor*” OR “knowledge retriev*” OR “knowledge work*” OR “knowledge disseminat*” OR “knowledge spill*” OR “knowledge transf*” OR “knowledge use*” OR “knowledge applicat*” OR “organizational knowledge*” OR “explicit knowledge*” OR “tacit knowledge”*))

The words determined by choosing the “TS” (Topic Search) operator on Web of Science were scanned in the title, abstract, and keywords sections of the articles. In the first scan in mid-2021, 1312 publications were accessed. In the second stage, the years between 2013 and 2020 were chosen to limit the time frame of the study. Since the number of publications in and before 2013 was limited to one or two studies, previous years were not taken into account. In addition to the year limit, only articles and reviews in English were selected to improve performance analysis outputs and make them unbiased. As a result of these search limits, our search query decreased to 725 articles. Finally, the titles and abstracts of the articles were scanned and the articles that were not suitable for the study were eliminated, and at the same time, the articles with missing bibliometric data (e.g. keywords, author affiliations, abstract) were excluded from the data set. With these eliminations, a total of 622 academic articles were included to use in bibliometric analyses.

Bibliometric Analysis Results

Descriptive Statistics

The present study provided descriptive information about the data set by using the general information obtained from 622 articles. As seen in Table 1, 546 of the total publications are research articles and 76 of them are review articles. The publications came from a total of 376 different sources. The number of publications per author is 0.327, while the number of authors per publication is 3.06. Considering that there are 63 articles in total with a single author, and that the Collaboration Index is 3.29, it is understood that the articles in the field were mostly written in collaboration. Collaboration index (CI) is a benchmark value calculated by dividing the number of authors in multi-author articles by the number of those articles. Figure 1 shows the distribution of articles by years. In 2013, a total of 12 articles were published, while in 2020, this figure increased to 146. The average annual growth rate in the number of articles was found to be 42.9%. This rate actually shows that the interest in the field has increased very rapidly and that the field will maintain its popularity in the coming years.

Table 1

Descriptive Statistics

#	Description	Results
Main information	Timespan	2013 : 2020
	Sources	376
	Total Documents	622
	Research Article	546
	Review Article	76
	Author's Keywords	2.190
	References	33.960
	Average citations per documents	12.79
Authors information	Authors	1.901
	Author Appearances	2.206
	Authors of single-authored documents	61
	Authors of multi-authored documents	1.840
Authors collaboration	Single-authored documents	63
	Documents per Author	0.33
	Authors per Document	3.06
	Co-Authors per Documents	3.55
	Collaboration Index	3.29

Table 2 displays the number of relevant publications in the journals. As illustrated in the table, while 270 of 376 journals published only one relevant article in the field, the number of journals that published 5 or more articles is 13. Table 3 shows the most leading journals in the field, which are "IEEE Access", "Journal of Knowledge Management", "Expert Systems with Applications", "Management Decision" and "Journal of Business Research", respectively. The first publications of these journals show that they entered the field in 2015, 2016, and 2017. Although that they were initiated in the field later than some other journals, their dominance in the field shows that they will be the dominant journals in the field in the coming years given the high number of publications and citations they receive.

Figure 1

Annual Production and Citation of Articles over Time

(Annual Growth Rate: 42.9%)

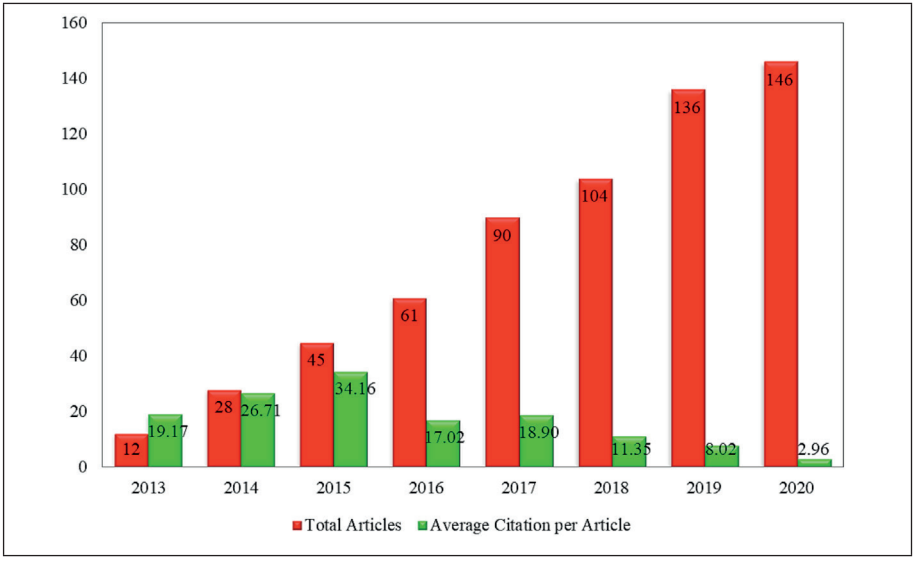

Table 2

Journal-Article Frequencies

Total Articles	Total Journals
1	270
2	66
3	16
4	11
5	1
6	2
7	1
8	4
9	1
10	2
21	1
22	1
622	376

Table 3

Most Productive 25 Journals

#	Source	Total Articles	First Publication Year	Total Citations
1	IEEE Access	22	2016	129
2	Journal of Knowledge Management	21	2016	404
3	Expert Systems with Applications	10	2015	245
4	Management Decision	10	2016	121
5	Journal of Business Research	9	2017	215
6	International Journal of Information Management	8	2018	185
7	Future Generation Computer Systems-The International Journal of E-science	8	2016	145
8	Technological Forecasting and Social Change	8	2018	101
9	Wiley Interdisciplinary Reviews-Data Mining and Knowledge Discovery	8	2016	80
10	Business Process Management Journal	7	2017	94
11	ISPRS International Journal of Geo-Information	6	2017	39
12	Sustainability	6	2018	27
13	International Journal of Digital Earth	5	2013	104
14	IEEE Transactions on Knowledge and Data Engineering	4	2016	138
15	Decision Support Systems	4	2015	96
16	Computers & Industrial Engineering	4	2017	85
17	Knowledge-Based Systems	4	2014	53
18	Information Sciences	4	2016	34
19	Applied Sciences-Basel	4	2018	13
20	PLOS One	4	2013	11

The Most Productive Authors, Institutions and Countries

Table 4 displays information on the productivity of the authors in terms of publications in the field of big data and knowledge management. The most productive authors in the field were Wu Chuanrong with 8 articles and Feng Li with 5 articles. Considering the authors unlisted, authors from China are in the majority with 1 and 2 articles each, indicating that the most productive writers in the field are from China. They are followed by authors working in the USA, UK, Germany and Italy, respectively. The

number of articles and revised articles by the authors signifies that the majority of the studies were prepared with collaboration and multiple study groups. The study groups of the authors are also given in the table, showing that writers of the same colour work together. The groups demonstrate that sample groups increase the productivity.

Table 4

Most Productive Authors

#	Authors	Articles	Articles Fractionalized	Country	Affiliation
1	Wu Chuanrong	8	2.98	China	Changsha University of Science & Technology
2	Feng Li	5	1.61	China	Changsha University of Science and Technology
3	Evgeniya Zapevalova	4	1.03	China	Changsha University of Science & Technology
4	Jörn Lötsch	4	1.28	Germany	Goethe-University
5	Alfred Ultsch	4	1.45	Germany	University of Marburg
6	Dario Kringel	3	0.78	Germany	Goethe-University
7	Helen N. Rothberg	4	2	USA	Marist College
8	G. Scott Erickson	3	1.5	USA	Ithaca College
9	Marcello Trovati	4	2	UK	Edge Hill University
10	Nik Bessis	3	1	UK	University of Derby
11	Giacomo Marzi	3	0.75	UK	University of Lincoln
12	Riccardo Rialti	3	0.75	Italy	University of Florence
13	David Camacho	3	0.75	Spain	Universidad Autónoma de Madrid
14	Cheng Fan	3	1	China	Shenzhen University
15	Eric Tsui	3	0.75	Hong Kong	Hong Kong Polytechnic University
16	Wei Fan	3	0.57	Hong Kong	Huawei Noah's Ark Lab
17	Wu He	3	1.03	USA	Old Dominion University
18	Francisco Herrera	3	0.71	Spain	University of Granada
19	Antonio Messeni Petruzzelli	3	0.88	Italy	Polytechnic University of Bari
20	Gabriele Santoro	3	0.75	Italy	University of Turin

Table 5 shows the total number of publications in the field as per countries. China is the leading country in terms of its highest contribution to the field of big data and knowledge management, with 140 articles. While 89 of these articles were published by authors from the same country (SCP- single country publications), 51 of them were published by authors from different countries (MCP- multiple-country publications). The second country with the highest number of publications was the USA with 126 articles. While 95 articles from US publications were produced by authors from the same country, 31 of them were written with the collaboration of authors from different countries. China and the USA were the two countries that published the most in this field and also their publications became the most cited publications. Apart from these two countries, Italy, United Kingdom, Germany, India, and Spain are among the main countries contributing to the field.

Table 5

Paper Frequencies of Countries

#	Country	Articles	SCP	MCP	Total Citations	Average Article Citations
1	China	140	89	51	1,592	11.37
2	USA	126	95	31	1,748	13.87
3	Italy	42	22	20	747	17.79
4	United Kingdom	37	22	15	692	18.70
5	Germany	23	17	6	287	12.48
6	India	22	19	3	256	11.64
7	Spain	21	13	8	291	13.86
8	Australia	17	11	6	234	13.77
9	France	13	8	5	150	11.54
10	Canada	12	6	6	199	16.58
11	Korea	9	6	3	62	6.89
12	Saudi Arabia	9	4	5	40	4.44
13	Brazil	8	5	3	33	4.13
14	Netherlands	8	7	1	108	13.50
15	Finland	7	3	4	6	0.86
16	Malaysia	7	3	4	94	13.43
17	Sweden	7	4	3	204	29.14
18	Iran	6	5	1	32	5.33
19	Norway	6	5	1	17	2.83
20	Pakistan	6	3	3	75	12.50

SCP: single country publications; **MCP:** multiple-country publications

Table 6 displays the institutions that published the most in the field in accordance with the corresponding authors in the articles. Moreover, universities in China and the USA are, similarly, at the forefront of the institutions that publish the most in the field. The top five institutions in the field include the University of Minnesota, Changsha Science and Technology University, Hong Kong Polytechnic University, University Missouri, and Tsinghua University, respectively. Overall, 70% of institutions in the top twenty are universities in China and the USA. Given that they are the most productive countries with the most productive writers and the most productive institutions in the field, China and the USA seem to be the leading countries in this sense.

Table 6

Most Productive Institutions

#	Affiliations	Articles	Country
1	University of Minnesota	23	USA
2	Changsha sci and technol university	22	China
3	Hong Kong polytechnic university	19	Hong Kong
4	University Missouri	18	USA
5	Tsinghua university	17	China
6	King Abdul-Aziz university	13	Saudi Arabia
7	University Salerno	13	Italy
8	University Turin	12	Italy
9	King Saud university	11	Saudi Arabia
10	Peking university	11	China
11	Beihang university	10	China
12	Dalian university technology	10	China
13	University of Illinois	10	USA
14	University Wisconsin	10	USA
15	Rutgers state university	9	USA
16	Shenzhen university	9	China
17	University of Granada	9	Spain
18	University of Michigan	9	USA
19	University of Salento	9	Italy
20	University of Texas Austin	9	USA

Figure 2 shows the country collaboration network obtained through the VOSviewer. Different colour groups indicate different clusters. When authors from different countries work collaboratively, those countries are connected to each other by nodes. As can be seen in Figure 2, the countries working in the field consist of 3 different clusters. The red cluster including the USA, China, Saudi Arabia, India, Malaysia, and Pakistan shows that the USA and China, the most dominant countries in the field, are working in collaboration. Since China and the USA are technology and knowledge-intensive economies, their high cooperation in the field is an anticipated outcome (Wu, 2020). The blue cluster includes countries such as Spain, Belgium, Austria, Denmark, Greece, and Turkey. In this cluster, the networks are mostly among European countries, mainly Spain. The green cluster, on the other hand, is a cluster in which France, Italy, and the UK are dominant, with intense collaboration with other countries such as New Zealand, Ireland, Portugal, Scotland, Slovenia, and Russia.

Figure 2

Country Collaboration Network

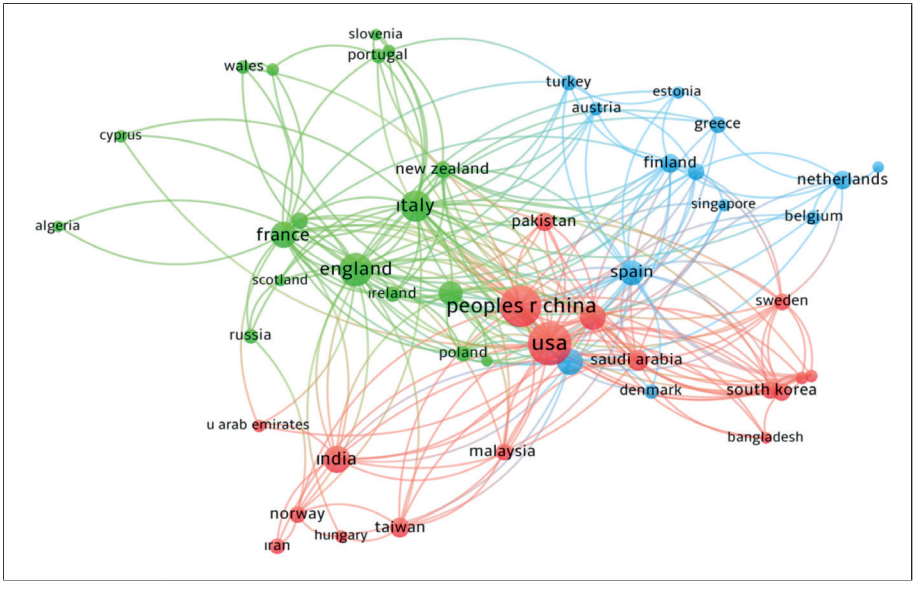

Figure 3

Institutional Co-authorship Network

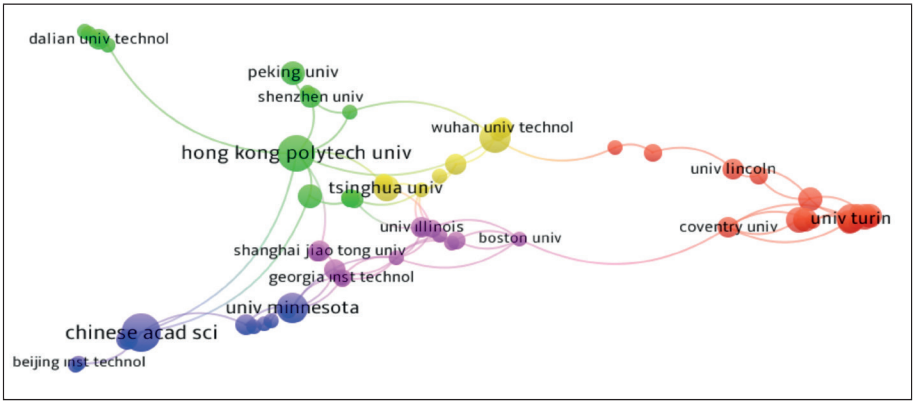

Figure 3 shows the network of collaborations between institutions. As is shown, the collaborations of research institutions are clustered in five different groups. Among the universities in the blue group, the Chinese Academy of Sciences (China), Beijing Institute of Technology (China), and University of Minnesota (USA) show that universities in China and the USA work in intensive collaboration. As the most productive university in the green group, Hong Kong Polytechnic University works in intensive collaboration with China-based Shenzhen University, Peking University, and Dalian University of Technology. The collaboration between the universities in Hong Kong and China stands out in this group. In the yellow cluster, collaboration among the universities in China is significant, while in the purple cluster, collaboration among US universities is dominant. The red cluster consists of collaborations between the institutions in Italy and the United Kingdom such as Coventry University (the UK), the University of Turin (Italy), and the University of Lincoln (the UK). This way of clustering is compatible with the country co-authorship network in Figure 2.

Keyword Analysis and Co-word Network

Table 7 shows the most frequent keywords in the articles and how many times they are used in total. Most frequently used words in the articles are "big data, management, performance, challenges, framework, and knowledge management". As a matter of fact, this is actually an expected outcome since it is of great importance to be able to determine the needs of management and businesses by using technological capabilities. The biggest expectation from the relationship between big data and knowledge management is to process organizational information in a way that supports management and business performance and to produce new knowledge by employing big data analytical techniques (Pauleen & Wang, 2017).

Table 7

Most Frequent Keywords

#	Words	Freq	#	Words	Freq
1	big data	130	26	networks	20
2	management	64	27	future	19
3	performance	60	28	capabilities	18
4	challenges	47	29	opportunities	16
5	framework	46	30	social media	16
6	knowledge management	46	31	algorithms	15
7	systems	46	32	big data analytics	15
8	analytics	45	33	strategy	15
9	information	44	34	algorithm	14
10	impact	42	35	data science	14
11	innovation	42	36	discovery	14
12	knowledge discovery	39	37	firm performance	14
13	model	37	38	network	13
14	knowledge	32	39	prediction	13
15	internet	29	40	absorptive-capacity	12
16	technology	29	41	decision-making	12
17	system	27	42	quality	12
18	intelligence	24	43	support	12
19	science	24	44	models	11
20	business intelligence	23	45	selection	11
21	classification	22	46	supply chain management	11
22	data analytics	22	47	technologies	11
23	information-technology	22	48	things	11
24	design	21	49	trends	11
25	firm	20	50	adoption	10

Figure 4

Co-occurrence Network of Author Keywords

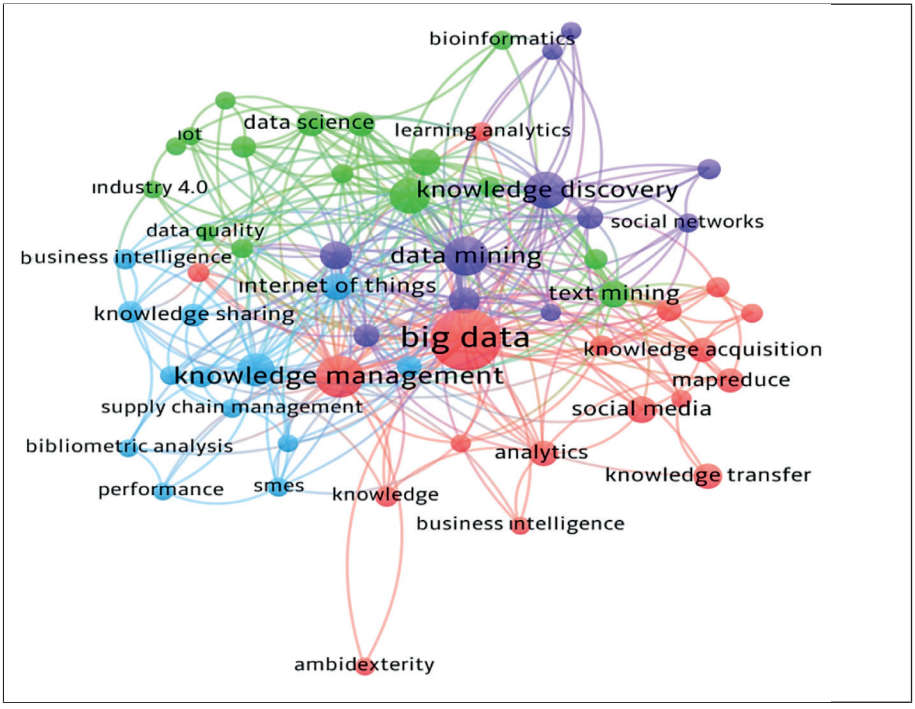

Figure 4 shows the co-occurrence network created with VOSviewer, using the author-keywords included in 622 studies. With this analysis, four different clusters emerged based on the frequency of co-occurrence of keywords. *The red cluster* contains words such as "big data, knowledge management, knowledge acquisition, social media, analytics, MapReduce, knowledge transfer". This cluster emphasizes the collection of big data from different sources and the management of knowledge by processing it through various analytical methods. *The blue cluster* includes the words "knowledge management, supply chain management, internet of things, knowledge sharing and performance", indicating that they are related to each other. This cluster delineates knowledge sharing through artificial intelligence techniques and their contribution to supply chain management and performance. *The purple cluster* comprises some frequent words such as "knowledge discovery, data mining, text mining, and social networks". This cluster mainly reveals the discovery of new information with various artificial intelligence methods such as data mining and text mining from among large data sets. Finally, in *the green cluster*, words such as "data quality, data science,

industry 4.0, learning analytics and bioinformatics" appear to have been used together intensively. As can be seen, this cluster draws attention to data science itself. By examining the data sets with artificial intelligence methods, the data is organized in such a way to enable an access to the meaningful information embedded in them. In this way, big data plays the enabler role for effective knowledge management.

Co-citation Analysis

Co-citation analysis in Vosviewer is a demonstration of networks that reveal the relationships between cited authors, sources, and references. Through co-citation analysis, the intellectual structure of the research field is revealed by discovering clusters of authors who have previously conducted similar studies and their sources (Shiau et al., 2017). In the event that two authors or two documents are cited together in another document, it is called co-citation (Xu et al., 2018). Co-citation analysis reveals clusters of publications, references, or authors cited together with other studies (Shiau et al., 2017). Figure 5 shows the co-citation network of authors, in which five different colours symbolize that the authors are clustered in five different groups. It is known that authors in the same group are cited together in publications as they have conducted similar studies. For example, the studies of the authors in the green group indicate that they mostly study the theoretical infrastructure of big data and the effects of data analytics on performance in businesses.

Figure 5

Author Co-citation Network

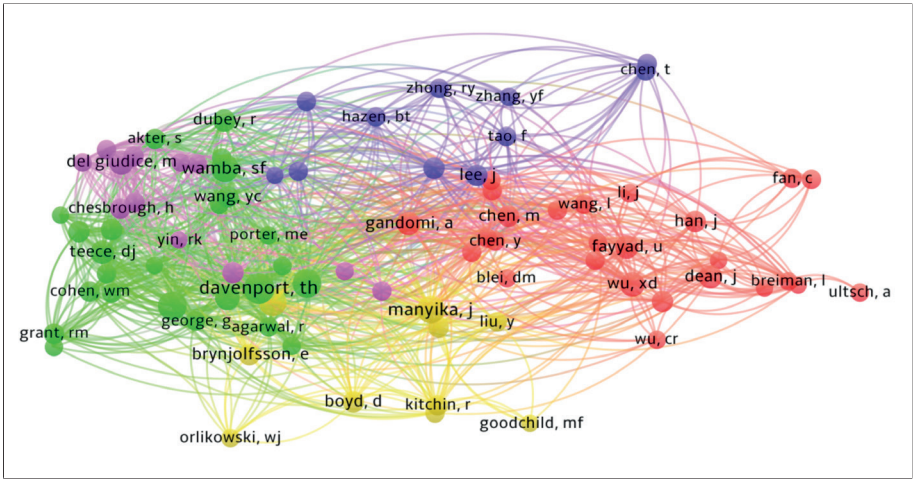

Figure 6

Source Co-citation Network

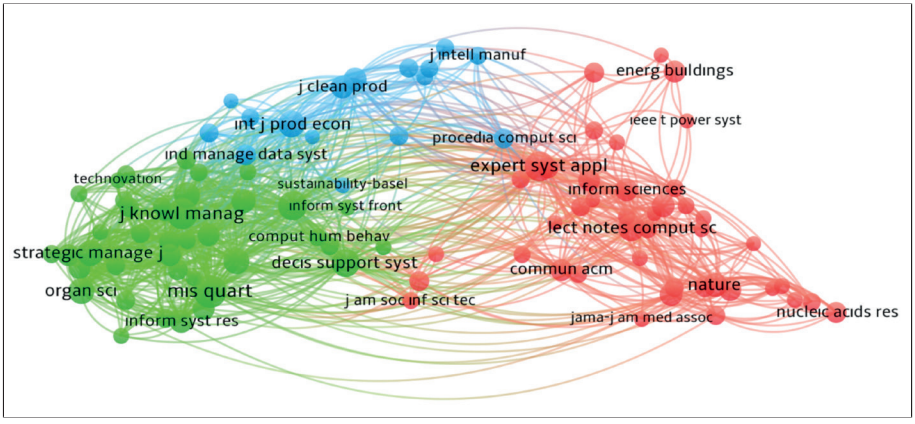

Figure 6 presents the co-citation network of cited sources. The three different colours in the figure show that the co-cited sources are generally clustered in 3 different groups. The larger the circle in which the names of the journals are mentioned, the more citations the journal receives. In this respect, the most cited journal among those in the red group is "Expert Systems with Applications", which can be found under the categories of "Computer Science, Engineering, Operations Research & Management" in the Web of Science database; likewise, other journals in this cluster also include academic articles in similar fields, but mainly in the field of computational sciences and applications. In this sense, it can be asserted that the studies that refer to these sources are those that associate big data with knowledge management by processing various mathematical and artificial intelligence applications. In the green cluster, on the other hand, the most cited journal is "Journal of Knowledge Management", which is an active journal in the fields of information science, business and economics; and the other relevant co-cited journals are in similar categories. The studies in this group mostly seem to focus on big data and knowledge management in the field of business and management. The most dominant journal in the blue cluster is the "International Journal of Production Economics", which mainly includes publications in the fields of engineering, manufacturing, and operations research, just as is the case with other journals in the group. It can be stated that studies referring to this group generally evaluate big data and knowledge management together in sustainability, environmental research, production, manufacturing, and process industries.

Conclusion and Discussions

The aim of this article is to examine the studies in the field of big data and knowledge management from a bibliometric perspective, and to create a general framework for the past, present and future of the field. One of the strengths of this research is the use of bibliometric analysis as it is multidimensional, dealing with many analyses in one study. In this context, 622 articles published between 2013 and 2020 were examined on the WoS database with bibliometric analysis. Descriptive statistics show that the interest in the field has increased considerably in recent years and the annual average increase in publication rate in the field has been found to be 42.9%. Based on this, the research field is expected to maintain its popularity in the coming years.

The two journals with the highest number of publications in the field are IEEE Access and Journal of Knowledge Management. China and the USA are the leading countries among those that contribute the most to the field. Likewise, the institutions that contribute the most to the field are in China and the USA. Collaboration seems to be intense in the publications of these two countries. It is obvious that China and the USA are two countries where both technology and information are potent. For this reason, the expectation that these two countries will be dominant in the field and that there will be intense cooperation between them has been confirmed by the analysis. Among European countries, an intense collaboration appears between the UK, France, Italy, and New Zealand.

In the co-word network (see Figure 4), it is evident that the keywords in the articles have been used intensively in four different clusters. Based on the keywords in the red cluster, it can be assumed that the publications in this specific cluster focus on collecting big data from various online platforms, processing it with analytical methods, and managing knowledge. It can be said that in the publications comprised in the blue cluster, big data is processed using developing artificial intelligence technologies and thus, valuable information is shared, contributing to supply chain management and business performance. In the purple cluster, there are studies dwelling on the discovery of meaningful new information from big data sets by the use of analytical methods such as data mining and text mining. In the green cluster, the studies seem to emphasize data science itself. Meaningful information can be acquired by focusing on the data itself through a number of data analytics techniques- especially learning analytics and bio-informatics-, in which complex data is compiled, defined, and processed. These studies have been of great importance recently, especially in terms of revealing the role of big data as an effective contributor to knowledge management.

In the source co-citation network analysis (see Figure 6), the sources are basically divided into three groups. The studies appearing in the journals in the red cluster are mostly in the fields of engineering and computer science, and relate big data sets to knowledge management by processing them with various mathematical applications

and artificial intelligence programs. It can be considered that the articles in this cluster provide meaningful information to be used in decision-making processes by supporting the field of knowledge management with various statistical analyses, artificial intelligence applications, mathematical models, and algorithms. In the green cluster, the journals are gathered mainly in the field of business and economy, focusing on revealing new information from big data in the field of business and economy, and providing support to management challenges such as decision-making, performance management, risk management, and customer satisfaction. The journals in the blue cluster are mostly concentrated around the fields of production, operational research, and engineering, mainly focusing on providing support to production processes, sustainability, supply chains, boosting production and service quality, demand forecasting, and inventory management by means of knowledge accumulated from big data sets.

The present study has important contributions to the literature both theoretically and practically. Studies that theoretically relate big data and knowledge management were examined from a bibliometric perspective and the development of the field was presented objectively. Although some recent studies (Chierici et al., 2018; Khan & Vorley, 2017; Pauleen & Wang, 2017; Sumbal et al., 2017; Tian, 2017; S. Wang & Wang, 2020) have revealed certain theoretical or experimental findings that relate big data and knowledge management in various ways, this study has presented multiple perspectives to authors by exploring the most effective publications, journals, authors, country collaborations, and co-citation networks in this particular field. Notably, co-word networks and source co-citation networks have provided guidance to researchers about how the studies in the field are clustered.

It has been understood that the intersection of knowledge management and big data with the co-word network has spread over a wide area. Accordingly, big data has become an important enabler for the development of knowledge management. In addition, it has been understood that digital technologies such as data mining, text mining, artificial intelligence, internet of things and learning analytics, which enable the processing of big data, will contribute to the development of the field of knowledge management. With source co-citation, it can be said that researches are generally shaped by artificial intelligence methods under computational sciences field, come to the fore with managerial applications in business and economics field, and are shaped by sustainability, production and process management under engineering and operations field.

The results of the study showed that in practice, the relationship between big data and knowledge management can yield meaningful results in many areas such as production, supply chain, engineering, decision-making, marketing, and sustainability. In particular, the development of techniques such as the internet of things, data mining, text mining, big data analytics, and learning analytics benefit the emergence of

embedded knowledge in big data sets and its use across organizations. For this reason, businesses can perform more effective knowledge management activities by having newly developing digital technologies to process big data. In this sense, big data and digital technologies to analyse big data sets has become an important resource for knowledge management. In addition, the fact that the most active countries in big data and knowledge management are China and the USA provides an important clue for executors to focus on studies and developments there.

Limitations and Future Directions

This study has certain limitations like any academic study. First of all, the relevant data were obtained from the WoS database, which is internationally acknowledged, containing a variety of high-quality studies of researchers. In future studies, researchers can reach more comprehensive results by taking into account the studies in other databases such as Scopus and EBSCO, which emphasize the quality and reliability of publications at the international level. Only academic articles were selected to reach more valid and reliable results within the scope of the data set. For this reason, other publication types such as book chapters and conference papers may be included in order to have a more holistic perspective in future studies. The present study analysed the data obtained from 622 articles by using certain keywords in the literature related to big data and knowledge management. Expanding the scope of keywords and analysing them with more words can enable researchers to obtain different results. We preferred not to restrict the research area while collecting data. Future researchers may conduct bibliometric analysis and systematic literature review in different sub-categories such as business, economics, engineering, communication, transportation, health, telecommunications, information systems, or computational sciences in order to reach more comprehensive information in the context of their research areas.

Conflict of Interest

There is no conflict of interest between the authors.

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Author Contributions

Planning the research, T.K., Y.S., and H.A.K.; conceptualization, T.K., Y.S., and H.A.K.; methodology, T.K., and H.A.K.; data collection, T.K.; formal analysis, H.A.K.; writing-original draft preparation, T.K., Y.S., and H.A.K.; writing-review and editing, T.K., Y.S., and H.A.K.; visualization, H.A.K. All authors have read and agreed to the published version of the manuscript.

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