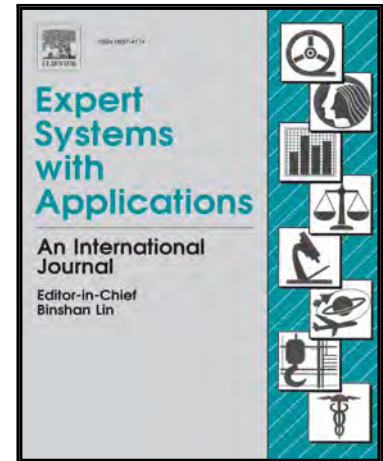


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Research Landscape of Business Intelligence and Big Data Analytics: A Bibliometrics Study

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## Research Landscape of Business Intelligence and Big Data Analytics: A Bibliometrics Study

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**Abstract**

*Business Intelligence* that applies data analytics to generate key information to support business decision making, has been an important area for more than two decades. In the last five years, the trend of “Big data” has emerged and becomes a core element of *Business Intelligence* research. In this article, we review academic literature associated with “Big data” and “Business Intelligence” to explore the development and research trends. We use bibliometric methods to analyze publications from 1990 to 2017 in journals indexed in Science Citation Index Expanded (SCIE), Social Science Citation Index (SSCI) and Arts & Humanities Citation Index (AHCI). We map the time trend, disciplinary distribution, high-frequency keywords to show emerging topics. The findings indicate that Computer Science and management information systems are two core disciplines that drive research associated with Big data and Business Intelligence. “Data Mining”, “Social Media” and “Information System” are high frequency keywords, but “Cloud Computing”, “Data Warehouse” and “Knowledge Management” are more emphasized after 2016.

Keywords: Bibliometrics, Big Data analytics, Business Intelligence, research trend.

## 1. Introduction

The rapid proliferation of information and communication technology has resulted in a rapid growth of digitized data and has also brought significant attention on research opportunities in big data analytics and business intelligence in management, social science, and humanity. The trend of big data and analytics for business intelligence provide great resources and powerful methodology to support the data-driven decision-making process, which is the core of “Business Intelligence.” Many enterprises today are utilizing big data to optimize their business intelligence process, while the academic research related to Big Data and Business Intelligence has thrived. The number of research papers is increasing very fast. Research topics range from concepts, methodologies, applications, and management. Hence, it is valuable to provide an overview of the published research so that interested scholars can easily know the research profile so far.

For this purpose, we conducted a Bibliometric study to examine the academic research output related to “Big Data” and “Business Intelligence” and analyzed publication data obtained from Web of Science, that includes papers indexed in Science Citation Index Expanded (SCIE), Social Science Citation Index (SSCI), Arts & Humanities Citation Index (AHCI), and Emerging Sources Citation Index (ESCI). The data period is from 1990 to December 31, 2017. Indexed publications with key words of “Big Data” and “Business Intelligence” in their title, abstract or subject are retrieved and analyzed. Findings are then presented.

## 2. Research Background

Both “Big Data” (BD) and “Business Intelligence” (BI) are fast growing key words in recent academic research. While “big data” becomes popular recently, “business Intelligence” was proposed much earlier. Luhn (1958) began to use the term “Business Intelligence” to describe an automatic system that disseminates information and supports decision-making process. The concept was later assimilated into the area of decision support and information systems. For instance, Vitt, et al (2002) defined business intelligence as a multifaceted concept that includes three different perspectives: making better decision faster, converting data into information, and using a rational approach to management (p.13). They define a BI cycle to include four phases: analysis, insight, action, and performance measurement. Turban, et al. (2005) further expanded BI to cover data warehouse, data acquisition, data mining, business analytics, and visualization.

The term “Big Data” was not mentioned until 2011. Berry (2011) first proposed the significance of “Big Data” to management in an academic publication. At the same time, McKinsey & Company (Manyika et al, 2011) also addressed that the technology and platform of “Big Data” had become a vital factor to enhancing a firm’s productivity and competitiveness. After these two seminal works, the publication of “Big Data” has booted exponentially.

In fact, BD and BI research has a substantial area of overlap, especially in Management-related fields. In general, BD emphasizes the data aspect that includes data collection, storage and analytics, while BI focuses more on data analysis, visualization and applications for business decision making. Previous research in these areas have significant overlap. For example, Tanev, et al. (2015) applies web search and online data reduction techniques to assess the value of product-enabled services. He, et al. (2015) analyzed social media data to obtain competitive intelligence. Griva, et al. (2018) analyzed market basket data to segment customers. In addition to marketing research, Moro, et al. (2015) summarized applications of text mining for business intelligence in banking. Sun, et al. (2014) examined business intelligence in real estates. Chung (2009) studied the effect of visualization in business intelligence. Brichni, et al. (2017) proposed a method to evaluate business intelligent systems. Above sample papers show the diversity of BD and BI research in recent years. They also indicate the value to provide a more comprehensive snapshot of research related to BD and BI.

### **3. Research Methodology**

In order to have a more comprehensive profile of BD and BI, we built our data set from Web of Science, an online subscription-based scientific citation indexing service originally produced by the Institute for Scientific Information (ISI), now maintained by Clarivate Analytics (previously the Intellectual Property and Science business of Thomson Reuters). We built the database and used the Bibliometrics methodology to map the time trend, the disciplinary distribution, the high-frequency keywords, the citation patterns and the topic evolutions of the related academic outputs. Citespace and VowsViewer were used to conduct the Bibliometric study.

Bibliometrics is a research methodology in the library and information science field. It is a statistical and quantitative analysis of academic outputs. It includes not only descriptive statistics but also network analysis on keywords, texts, citations, authors, institutions and their connection. Frequency, connection, centrality and cluster of authors and texts are investigated. Researchers use Bibliometrics to explore the

publication trend, knowledge base, citation pattern, author network, reader usage, impact and importance of a subject or a paper.

The bibliometric analysis allow us to answer the following questions:

- How the academic outputs related to “Big Data” and “Business Intelligence” have grown and evolved in the last decade?
- How research topics change and evolve in these academic outputs?
- Which discipline drives the related research?
- Who are major contributors toward these outputs? Which paper is the most influential?
- What are the most-cited references to these outputs?

Our search using “big data” and “business intelligence as key words resulted in the database that includes 10,637 publications associated with “Big Data” and 1,168 publications associated with “Business Intelligence.” Among these documents, 141 publications contain both “Big Data” and “Business Intelligence.”

#### 4. Time Trend of Publications

The first analysis is publication trend. Figure 1 shows the time trend of “Big Data” and of “Business Intelligence.” Less than 38 academic outputs of “Big Data” were found until 2011. The number increased to 92 in 2012 and multiplied very quickly afterward. In the single year of 2016, the number of BD publications went up to 3,287. In contrast to “Big Data”, the number of BI publications stayed relatively stable over the years. The trend of “Business Intelligence” started long before 2012, and increased to 48 in 2008, much higher than that of BD. However, the number only increased to 183 in 2016. This may be because BD as a technology has a much broader research coverage than BI that focuses on business applications.

We also examine the 141 papers that simultaneously include “BD&BI” as key words . Figure 2 shows the time trend of BD&BI publications. The number of these publications significantly increased to 32 in 2015 and continued to grow, but it is still not comparable to that of BD papers. The reason behind the small publication number could be that although the applications of BI and BD usually overlap, most papers may choose to show their major orientation as either technical or managerial. Another possibility is that big data is much of a buzzword that has been used extensively in commercial outlets also, while business intelligence is more restricted to certain

business domains. Hence, most papers prefer BD over BI.

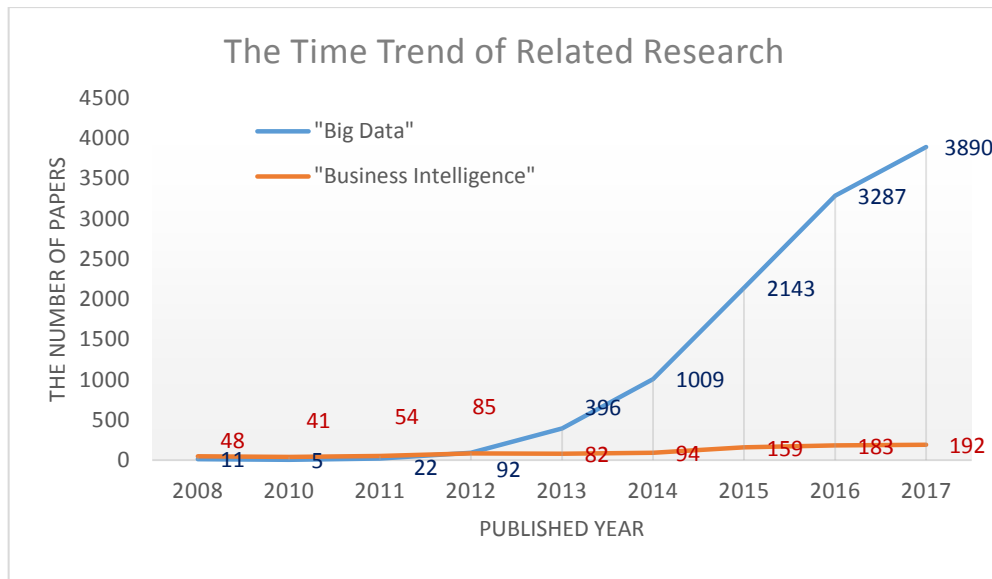


Figure 1: Time Trend of BD and BI Research

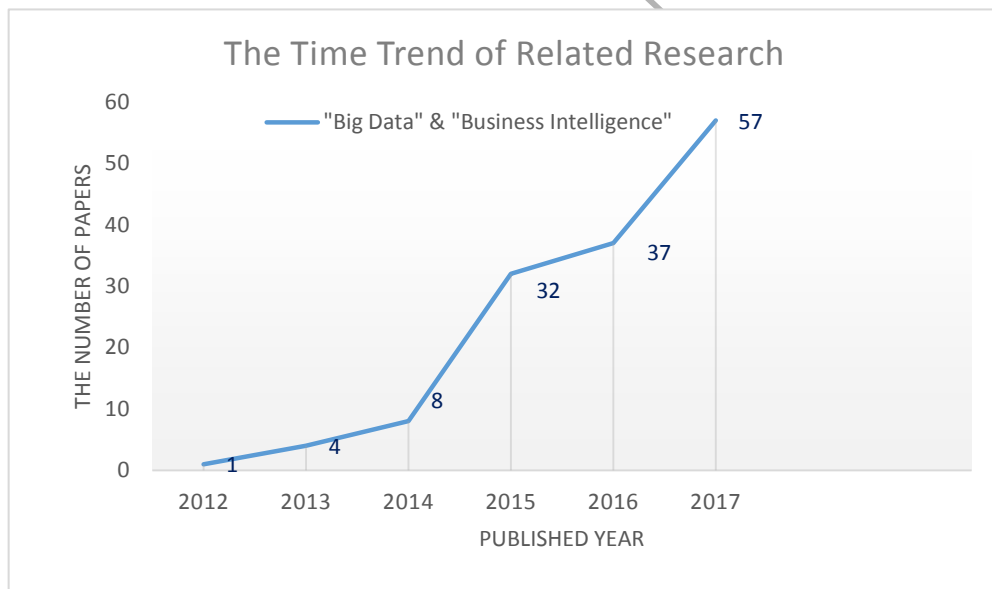


Figure 2: Trend of Research with both BD and BI

Table 1 presents the statistics of document types in the data set. Our data set include publications of article, editorial material and book reviews. Among the 10,637 publications of “Big Data”, 77.52% are articles, 10.63% are editorial materials, and 6.58% are reviews. Among the 1144 publications of “Business Intelligence”, 89.97% are articles. For “BD&BI” research, 85.1% are article. In Table 1, the summation of the percentages may exceed 100% and the record count may exceed the total number

of the publications because the Web of Science sometimes categorizes a publication into two different types.

**Table 1 Type of the Publications**

Document Type	Big Data		Business Intelligence		Big Data & Business Intelligence	
	Count	%	Count	%	Count	%
Article	8429	77.52%	1067	89.97%	120	85.10%
Editorial material	1156	10.63%	35	2.95%	8	9.22%
Review	716	6.58%	35	2.95%	13	5.67%
Book review	98	0.90%	17	1.43%	-	-
Meeting abstract	309	2.84%	18	1.52%	-	-
Proceedings paper	194	1.78%	71	5.99%	3	2.13%

## 5. Major Keywords and Topics

Table 2 summarizes the high frequency keywords of the “Big Data” and “Business Intelligence” publications. The keywords are listed in descending order of frequency. Among the 10,637 “Big Data” publications, the top 5 associated keywords are “model”, “algorithm”, “system”, “MapReduce” and “cloud computing”. Among the 1,168 “Business Intelligence” publications, the top five keywords are “management”, “data warehouse”, “big data”, “data mining” and “systems.” Although a few keywords such as “data mining”, “social media” and “management” are overlapped, we see significant discrepancy between these two groups of research. BD-related keywords are more emphasize on algorithm and computing, while BI-related keywords are more focused on management and decision support systems. The evidence is consistent with our argument that BD is more technical whereas BI is more application-oriented.

**Table 2 High-Frequency Keywords in Related Publications**

High Frequency Keywords			
Literature of "Big Data"		Literature of "Business Intelligence"	
Key Words	Occurrences	Key Words	Occurrences
model	549	management	109
algorithm	480	Data Warehouse	104



system	401	big data	84
MapReduce	389	Data Mining	91
cloud computing	376	systems	81
management	363	model	79
networks	347	performance	66
information	308	data analytics	61
Classification	307	knowledge management	54
Data Mining	280	information	52
Machine Learning	262	social media	46
performance	262	information systems	44
social media	255	design	40
privacy	240	olap	39
internet	233	web	38
surveillance	215	decision support system	37
data analytics	205	competitive intelligence	29
hadoop	186	information technology	28
prediction	181	business analytics	27
optimization	176	decision making	26
internet of things	167	design science	26

Figure 3 shows the visualized cloud of keywords in the 10,637 BD publications. Important keywords are highlighted with larger fonts, while the color of a keyword is determined by the cluster to which the keyword belongs. Lines among key words indicate the strongest co-citation links between keywords. “Big Data” is the center of the cloud since it is the search key. Consistent with Table 2, “model”, “algorithm”, “system”, “cloud computing”, “management”, “networks” and “information” are all highlighted key words. In the tag cloud, five main clusters labeled by different colors belong to 5 different main areas. The red cluster is formed by healthcare area publications, and the green cluster belongs to computer science area. “Business Intelligence” is on the top front belonging to the yellow cluster. The yellow cluster mainly belongs to the management field. “Business Intelligence” is directly linked with “management”, “data analytics” and “predictive analytics”, while “knowledge management” is bigger in the same cluster.

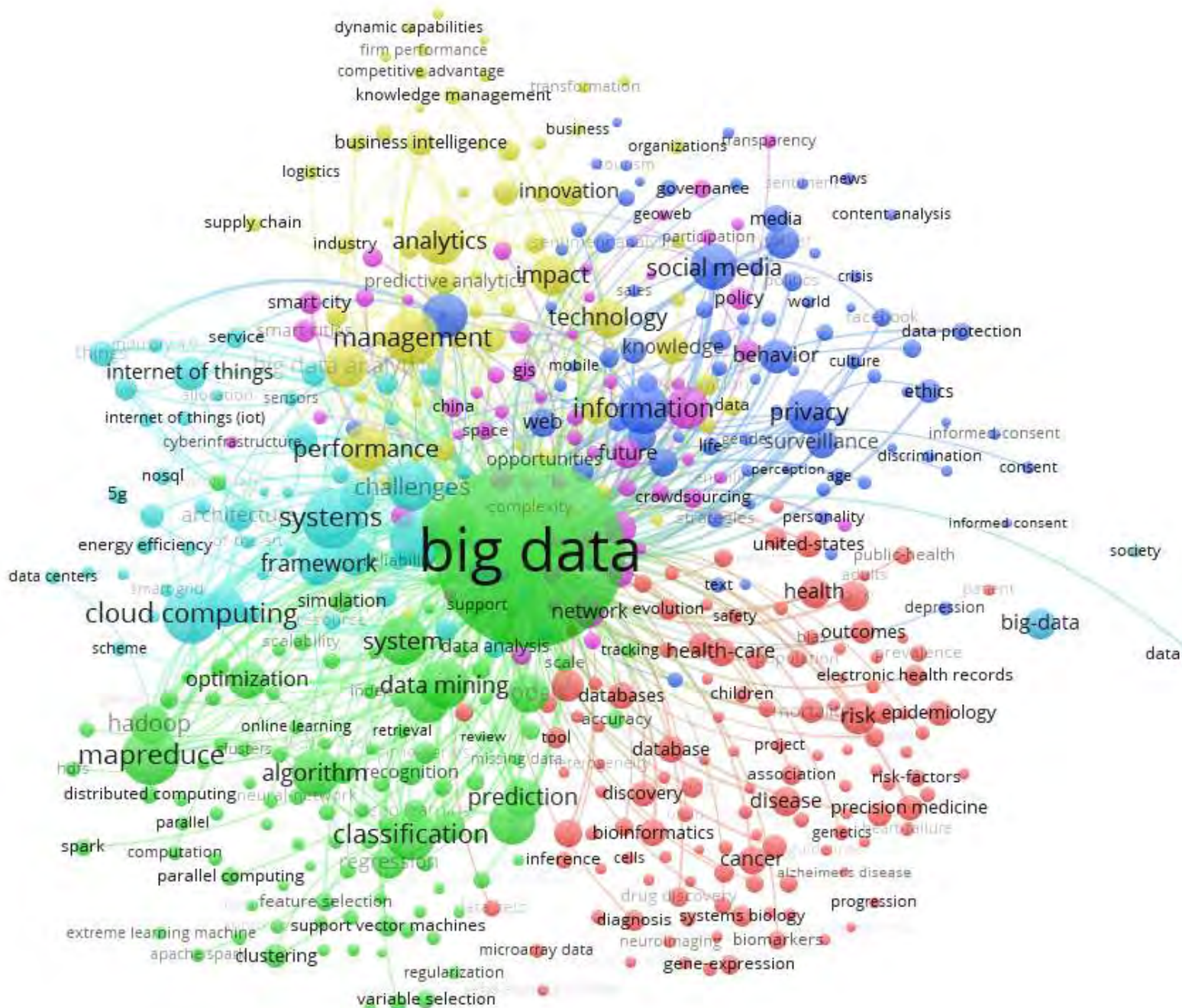


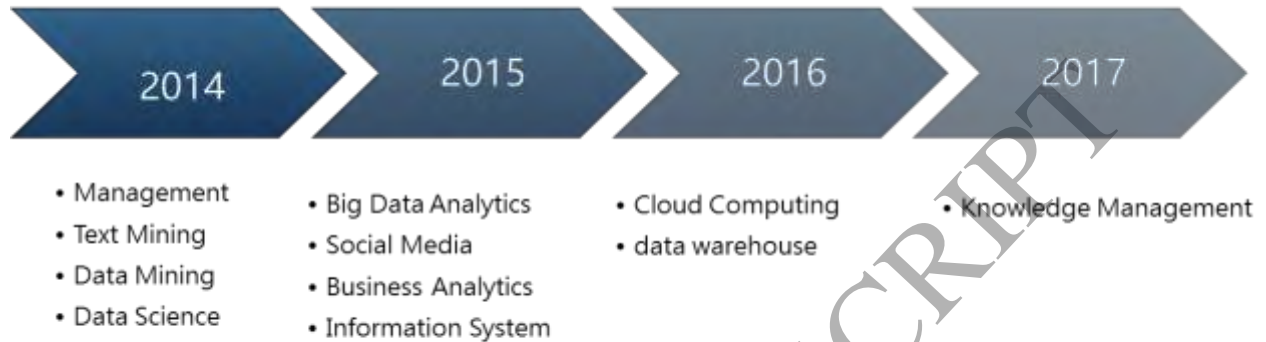
Figure 3. Word Cloud of Associated Key Words

## 6. Evolution of Keywords and Topics

The 10,637 BD publications covered a wide range of fields. To be more focused, we give a closer look at the 141 publications with both BD and BI as key words. Among these BD&BI publications, “Management” is the most frequent keyword, followed by “Big Data Analytics”, “Data Mining”, “Social Media” and “Information System”.

Figure 4 shows the evolution of high-frequency keywords in chronological order. The

timeline shows that “Cloud Computing”, “Data Warehouse” and “Knowledge Management” are more emphasized in 2016 and 2017. Compared to the keywords such as “Data Mining”, “Text Mining” and “Data Science” in 2014, research focus has shifted after 2016.



**Figure 4 Evolution of top keywords in “BD&BI” publications**

Given the popularity of BD and BI, many special issues on these topics have been published. The publication of special issues may be another way to observe research evolution as special issues show interests of academic journals. Figure 3 shows the journal special issues that we found. MIS Quarterly (2012) published the first Special Issue on Business Intelligence Research to identify the evolution and applications of Business Intelligence & Big Data (Chen et al., 2012). Papers in this special issue utilize text analysis, web analysis, network analysis in finance, bank, customer service and other industries. Most other special issues are published in or after 2016. For instance, IEEE Transactions on Cybernetics (2016) published a special issue on “Risk Intelligence in Big Data Era”. This special issue highlights how to build an effective data-oriented risk analytics system (Wu et al., 2016). Most recently in December 2017, Information System Frontier (Huang et al., 2017) also published a special issue that emphasized more on cloud-based issues such as cloud storage and cloud computing. This trend toward cloud-based issues echoes to the evolution of keywords over time. Expert Systems with Applications publish this special issue on big data analytics for business intelligence in 2018. A special issue focused on the strategic value of big data analytics will appear in the Journal of Management Information Systems in 2018.

**Table 3 Special Issues on Big Data and Business Intelligence**

Name of the Journal	Publish Date	Topic and Title
MIS Quarterly	2012	Business intelligence research
IEEE Transactions on Cybernetics	2016	Risk Intelligence in Big Data Era

Information Technology Tourism	2016	Business intelligence and big data in the travel and tourism domain
Journal of Marketing Management	2016	Brand marketing, big data and social innovation as future research directions for engagement
IEEE Computational Intelligence Magazine	2016	Computational Intelligence for Big Social Data Analysis
MIS Quarterly	2016	Big data and analytics in networked business
Information Systems Frontiers	2017	Big Data Analytics and Business Intelligence in Industry
Journal of Knowledge Management	2017	Does Big Data Mean Big Knowledge? Knowledge Management Perspectives on Big Data and Analytics
Expert Systems with Applications	2018	Big Data Analytics for Business Intelligence
Journal of Management Information Systems	2018	Strategic Value of Big Data Analytics for Business Intelligence

To further examination of BD research in social science and humanity journals, 2819 papers among the 10,637 BD publications were identified and analyzed. Figure 5 shows the time-line view of keywords in the citation networks of these 2,819 publications.

The keyword coded as "0" is "cardiovascular disease", the earliest subject coming out with the papers published before 2013. It shows that medical-related issues are where BD started in social sciences. It also echoes the fact that health care service is the most important field for BD applications. This is probably due to the availability of healthcare data from insurance companies and hospitals.

Among the ten topics in Figure 5, we can see that the topic of "agenda setting" (#4) may have come to an end. Research on agenda setting was documented as early as 2007 and became popular in 2009. In 2014, there were still many papers referring to "agenda setting" (the circle size reflects popularity of publication), but almost none was cited after 2015. It may indicate that the studies involving "agenda setting" in BD had come to an end.

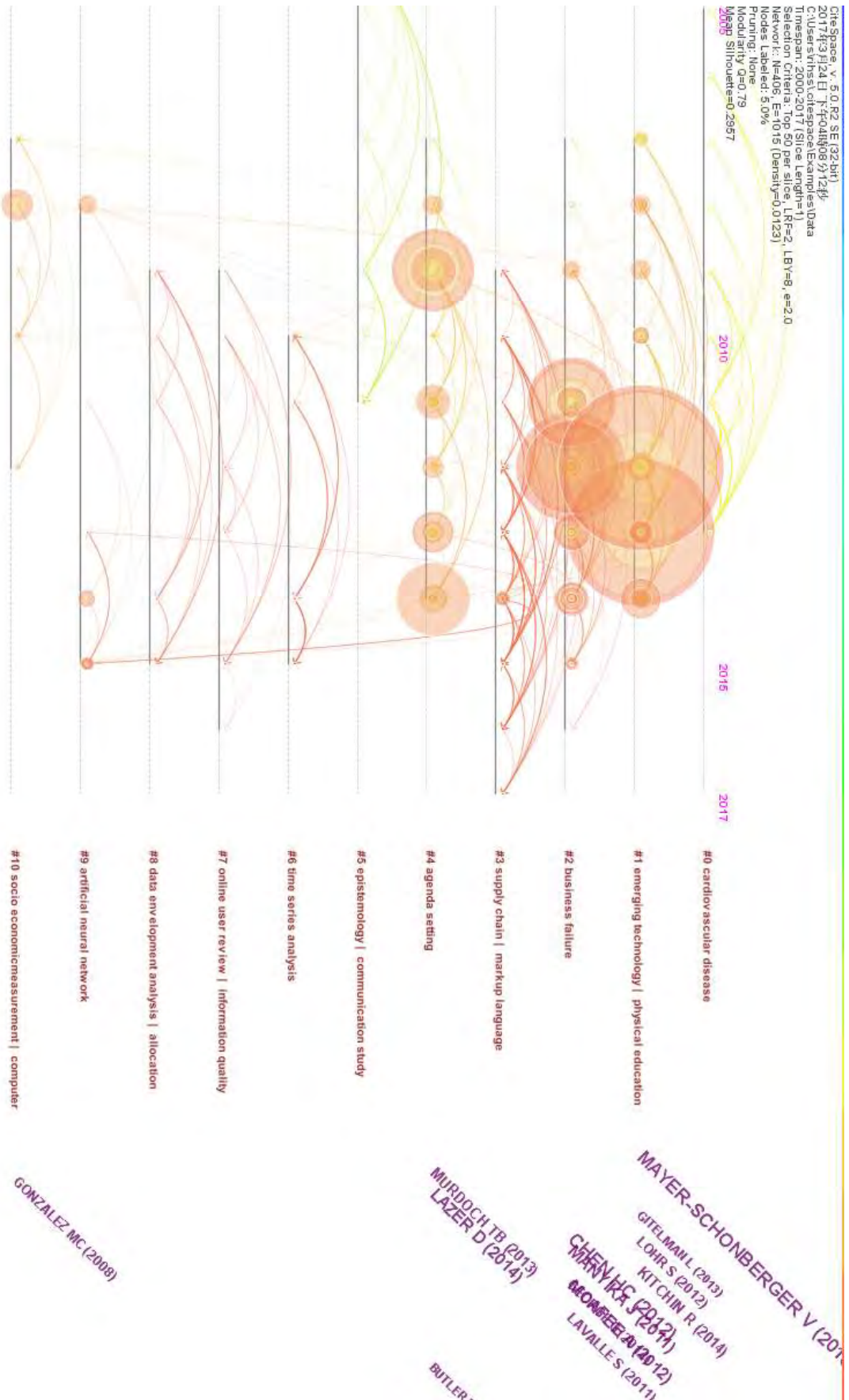


Figure 5 Timeline View of the “Big Data” Cited Network

Figure 5 also shows that "business failure" (#2), "online user review" (#7) and "supply chain" (#3) are areas that have attracted attentions continuously. These three long-lasting key words are all important topics in management field. "Business Failure" reached a peak referential period in 2012 and had been published as latest as 2016. "Supply chain" has been constantly discussed and cited in every time period and is one of the few items still being investigated in 2017 and 2018, though the number of relevant papers is smaller than other subjects. "Online user review" has less citations than "business failure" and "supply chain", but is still cited and discussed from the beginning to 2016.

## 7. Disciplinary Distribution and Major Journals

Another issue we may look into is the disciplines involved in BD and BI. We use special issues published by research journals as our evidence. Table 4 summarizes the academic fields of eight special issues on BD and BI. Three journals fall into the Computer Science field, and the others are related to Information Science and Management. This implies that Computer Science has been the core discipline that drives the research on BD and BI, while information science and management are also important disciplines.

**Table 4 Journals that Publish Special Issues on BD and BI**

Name of the Journal	Publish Date	Academic Fields
MIS Quarterly	2012 2016	Computer science, Information systems, Management
IEEE Transactions on Cybernetics	2016	Computer science, Cybernetics, Artificial intelligence
Information Technology Tourism	2016	Information Systems, Tourism
Journal of Marketing Management	2016	Management, Marketing
Information Systems Frontiers	2017	Computer science, Information systems, Theory & methods
Journal of Knowledge Management	2017	Information science & Library science, Management
Expert Systems with Applications	2018	Computer science, artificial intelligence, Engineering, Operations research & management science

Journal of Management Information Systems	2018	Information systems, Management
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Table 5 presents the top 10 journals that published the highest number of BD and BI papers in descending order. We can find that these two groups of journals have overlaps, but their top lists are quite different. Compared to BI papers mainly published in computer science journals, information system and management journals, BD papers were published in more diversified journals that emphasized interdisciplinary applications. Three journals are specific to BD and claimed to be multidisciplinary. To sum up, journals that publish BI research are more related to management fields while journals that publish BD research are broader.

**Table 5 Major Journals Which Published Most Big Data and Business Intelligence Research**

Big Data			Business Intelligence		
Journal	Counts	Associated Fields	Journal	Counts	Associated Fields
IEEE access	124	Computer Science, Information Systems, Electrical & Electronic Engineering	Expert Systems with Applications	38	Computer science-artificial intelligence, Engineering, Operations research & Management science
Plos One	102	Multidisciplinary Social Sciences	Decision Support Systems	35	Computer science- artificial intelligence, information systems, Operations research & management science
Future Generation Computer Systems	98	Computer science -theory & methods	Lecture notes in Computer Science	26	Computer science
Big data	85	Computer Science- interdisciplinary applications	Information Systems Management	23	Computer science- information systems
Concurrency and Computation-Practice & Experience	84	Computer science-software engineering, theory & methods	International Journal of Information Management	21	Information science & library science
Cluster Computing: the Journal of Networks, Software Tools and	77	Computer science- theory & methods information systems	Journal of Computer Information Systems	15	Computer science, information systems

Applications					
Neurocomputing	75	Computer science -artificial intelligence	Knowledge Based Systems	14	Computer science- artificial intelligence
Agro FOOD Industry Hi Tech	69	Biotechnology & Applied Microbiology; Food science & technology	Industrial Management & Data Systems	13	Computer science- Engineering-industrial
Journal of Supercomputing	64	Computer science-hardware & architecture, theory & methods; Engineering-electrical & electronic	International Journal of Data Warehousing and Mining	13	Computer science- software engineering
Information Sciences	55	Computer science- information systems	Information Systems Frontiers	12	Computer science- information systems

## 8. Major Authors and Influential Publications

Our dataset allows us to find most influential authors and most cited papers among these 141 BD & BI publications. Table 6 lists the publications with the most citation and centrality in the academic networks. “Citations” are the frequency of being cited in the whole data bank, while “Links” is the frequency of being linked among the 141 BD-BI publications Both Citations and Links measure publication importance and author influence.

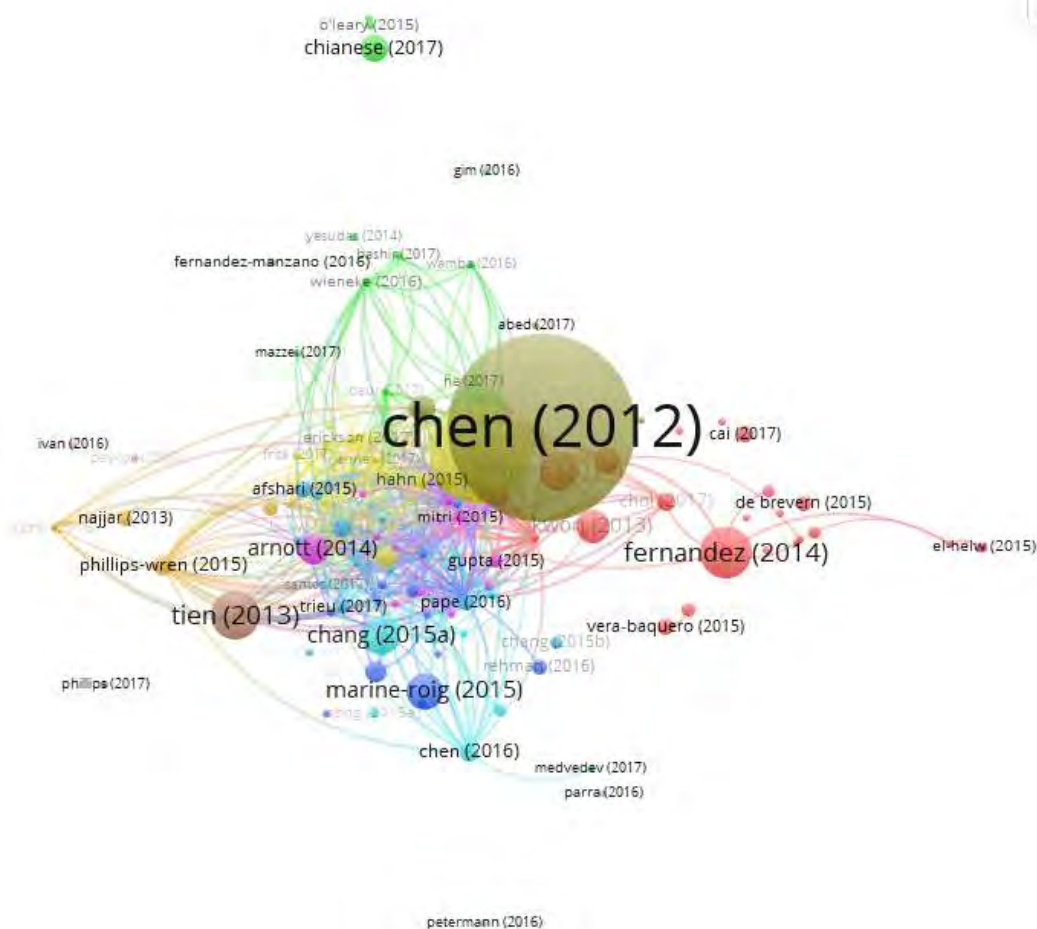
**Table 6 Most Cited Publications**

Publication	Citations (in WOS Data Bank)	Links (Among the 141 Publications)
Chen et al. (2012)	634	50
Wang et al. (2015)	162	9
Tien, J. M. (2013)	41	4
Chang, Y. W., Hsu, P. Y., & Wu, Z. Y. (2015)	29	3
Freire et al. (2016)	46	0
He et al. (2015)	25	2
Fuchs et al. (2014)	24	2



Kwon & Sim (2013)	22	0
Marine-Roig & Clavé (2015)	21	2
Arnott & Pervan (2014)	14	2

Table 6 shows that, among these 141 BD & BI publications, Chen et al. (2012) is the most influential paper with 634 times of citations and involvement in 50 links. This is because it is the position paper of the first special issue published in MIS Quarterly. The second influential publication is Gandomi, et al. (2015), followed by Tien et al.(2013) and Chang et al. (2015). These are important literature and the knowledge base for later BD & BI research.



**Figure 6 Visualization of the Bibliographic Coupling Network**

Figure 6 visualizes the bibliographic coupling network of the BD&BI publications. Bibliographic coupling measures the similarity relationship of publications based on their reference. Two papers are “coupled” when they both cite a third work in common. Two documents are bibliographically coupled if they both cite one or more documents in common. As in the citation network, Chen et al. (2012) is the core literature in the BD & BI bibliographic coupling network. Tien (2013) and Fernández

(2014) are also significant nodes with high popularity. This supports the previous argument that these three papers are important to BD&BI literature.

## 9. Future Research Directions

Given the profile indicated in previous analysis, we are able to identify a few key directions for future research. Figure 7 shows a general framework that divides research topics into four dimensions: technology, applications, management, and impact. Within each dimension, many possible topics need to be further explored. The technology dimension, for instance, includes issues related to data collection, storage, analytics, and integration infrastructure. For example, sentimental analysis needs to collect and analyze textual data properly. Technology for parsing the collected textual data properly and defining positive or negative emotion are also key research issue.

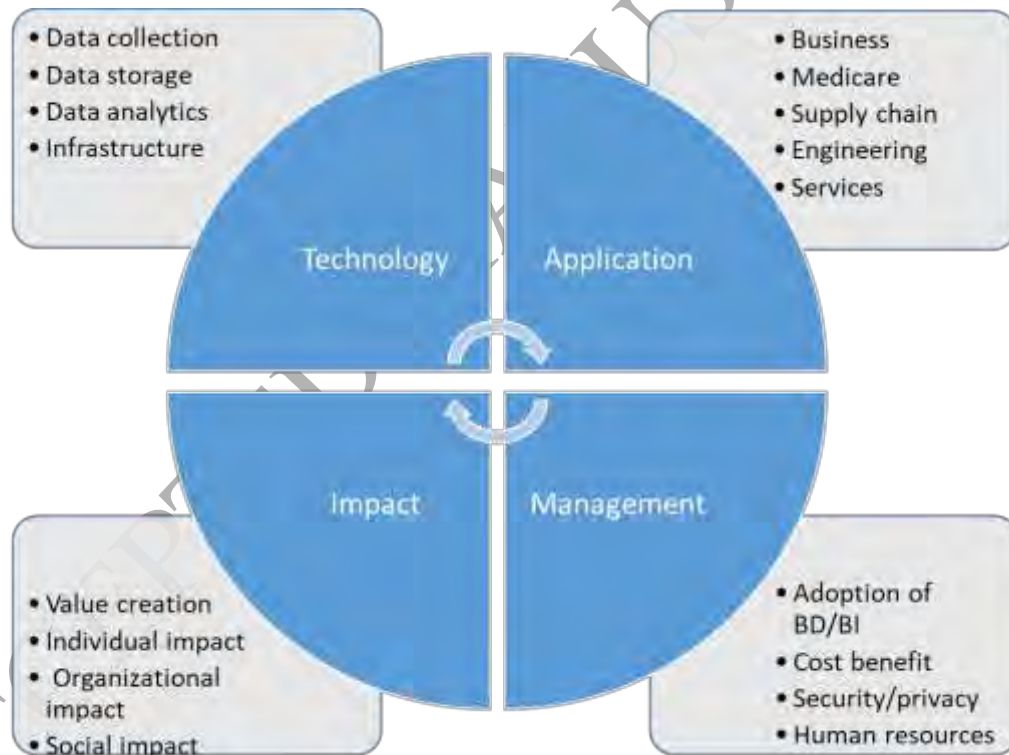


Figure 7. Framework for BD and BI Research

Application issues are those associated with applying certain technology to a specific domain. For instance, business applications are oriented toward profit making, while medical applications may focus more on accuracy or calculation efficiency. Risks involved in different application domains may be important too. For example, marketing plan derived from inaccurate segmentation of customers may cause

monetary loss but prescription from wrong patient diagnosis may result in loss of life that is totally unacceptable. Hence, researchers need to take concerns unique to application domains into consideration when they conduct BD/BI research.

Management issues include factors that affect the adoption of BD/BI technology, the cost-benefit assessment when the technology is to be adopted, security and privacy issues involved in BD/BI, and organizational readiness (e.g., human resources) of adopting BD/BI. A number of theories related to the adoption of information technologies are available. They are helpful in investigating why BD/BI is adopted or not adopted. Security and privacy issues are big concerns as well from the management perspective.

The impact of BD/BI is another dimension that has not yet been thoroughly studied. Most previous research focus on the positive side of BD/BI for promoting the technology, but has yet to prove the value creation from BD/BI or the avoidance of negative impact. Most existing case reports are based on anecdotal evidence. We need more large-scale research to verify the value of BD/BI, both strategic and managerial values. We also need research to investigate the impact (both positive and negative) of BD/BI on individual life, organizational operations, and social activities. For instance, how would location or traffic data of users collected from mobile Apps (e.g., Google map) may enhance the safety (or police beat) in a community with minimum invasion into individual privacy.

## **10. Concluding Remarks**

This paper reports results from a bibliometric analysis on published academic papers associated with “Big data” and “Business Intelligence”. Using CiteSpace, VOSViewer and descriptive statistics, we analyzed publication data from 1990 to 2017 in journals indexed in Science Citation Index, Social Science Citation Index and Arts & Humanities Citation Index. A total of 10,637 publications with “Big Data” as key words and 1,168 publications with “Business Intelligence” as key words were identified and analyzed. The time trend, their disciplinary distribution, high-frequency keywords and topic evolutions of these academic outputs have been reported.

A few major findings have been found. First, although “Business Intelligence” emerged long before “Big Data” and has grown steadily, its growth rate is below that of BD publications, which has increased explosively after 2013. This reflects the huge interests in BD research in recent 5 years.

Second, BD and BI papers appeared in different journals. BD papers were published in Computer Science oriented technical journals, while BI papers mainly appeared in management and information systems journals. Coverage of research topics related to BD are broader and more interdisciplinary than those of BI papers.

Third, interested topics also differ as observed by the difference in popular keywords. High frequency keywords associated with BD research are related to algorithm and computing, while those associated with BI research are more focused on management and decision support. In Big Data literature, the keyword “Business Intelligence” is directly linked to “management”, “data analytics” and “predictive analytics”, which shows the nature of BI research.

Fourth, a few papers have been well-cited and become knowledge core of BD and BI research. From the citation of 141 papers with both BD and BI as keywords, we find Chen et al. (2012) to be the most popular one. Tien (2013) and Fernández (2014) are also significant nodes. “Data Mining”, “Social Media” and “Information System” are high frequency keywords, while keyword “Cloud Computing”, “Data Warehouse” and “Knowledge Management” emerged in 2016 and 2017.

Finally, a few directions for future research has been proposed. Scholars interested in BD and BI research may follow the framework shown in Figure 7 of this paper to position their research. Journal editors may think of what research topics fit journal themes when they accept papers for publication.

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