International Journal of Economics, Business and Management Research

Vol. 4, No. 12; 2020

ISSN: 2456-7760

BIG DATA APPLICATION: FROM IDENTIFYING BARRIERS TO FINDING SOLUTIONS

Giang Thi Nguyen[1,2], Shu-Yi Liaw[3],*

[1]Department of Tropical Agriculture and International Cooperation, National Pingtung University of Science and Technology, Taiwan

[2]Department of Economics and Rural Development, Thai Nguyen University of Agriculture and Forestry, Vietnam

[3]Department of Business Administration and Computer Centre, National Pingtung University of Science and Technology, Taiwan *Tel: +886 -8-7703202 (ext. 6140)

Abstract

The rapid advancement of information and communication technology leads to a massive-scale data accumulation. This type of massive data is presented in structured, semi-structured and unstructured styles which are generated, recorded, stored and accumulated, to form big data (BD). BD has contributed immensely to improvements in several organizations and sectors upon application. However, due to the overrun of a data-driven revolution in management, a huge number of organizations are facing many barriers when they apply big data. It is crucial to get a better understanding of barriers organizations encounter when big data application is used. Based on a systematic review method, this article summarizes barriers to the adoption of big data including data, technology, organization, and environment. Thenceforth, the study also proposes potential solutions and to help organizations deal with the barriers of applying big data. Finally, a cycle of sustainable management for big data adoption is represented. This study is helpful for researchers and organizations to apply big data in the future.

Keywords: Barriers, big data adoption, data, environment, organization, technology

1. Introduction

The development of internet technology continue to improve vastly and has created a huge amount of big data from many different sources such as Media, Cloud, Web, Internet of Things, and Databases. BD sources are characterized by "5Vs" including, volume, velocity, variety, verification and value (Yuri Demchenko, 2013; Zhong *et al.*, 2016). Big data is groundbreaking technological development that enables innovation for change in infrastructure of organization (Günther *et al.*, 2017). The use of BD in market research analysis provides many benefits that enhance the prediction of future product development trends, and improvement of company-customer relationships (Le & Liaw, 2017). Furthermore, applying big data with modern analytical tools can provide useful insights, making it easier for managers to make decisions (Raguseo, 2018). Applying big data today brings numerous benefits for companies including increasing their performance, improving strategic direction, developing more credible customer service, identifying and developing product, and reducing communication costs (C.L.Philip Chen & Zhang, 2014; Coleman *et al.*, 2016; Muhammad Habibur Rehman *et al.*, 2019; Raguseo,

Vol. 4, No. 12; 2020

ISSN: 2456-7760

2018). According to Wang *et al.* (2018) BD has an pivotal role in business development and establishing a more sustainable economy.

Aside from the benefits of applying big data, organizations are also faced with challenges that may affect the smooth operations, management and transition of businesses. This issue has been addressed in several studies (Alharthi *et al.*, 2017; C.L.Philip Chen & Zhang, 2014; Coleman *et al.*, 2016; Luna *et al.*, 2014; Malaka & Brown, 2015b; Moktadir *et al.*, 2019). However, most studies show barriers to the application of big data by specific regions and fields. There are few studies summarizing all barriers affecting organizations' application of big data. Hence, the objectives of this paper are to:

1) Provide an overview of the barriers that organizations are facing.

2) Propose solutions and a cycle of sustainable management for big data adoption in organizations.

This study consists of six main parts. Firstly, an introduction which includes the reasons for conducting this research. Secondly, a theoretical background of the research related issues are presented. The third section constitutes of the research methods. The fourth part presents the findings of the research. Next, managerial implications are presented and the final part is the conclusions and limitations in future research.

2. Theoretical background

2.1. Definition of big data

Data sources composed of huge capacity, complexity, and traditional data tools which cannot be analyze easily is termed as "Big Data" (Min Chen *et al.*, 2014). Saggi & Jain (2018) categorized big data according to volume, velocity, variety, valence, veracity, variability, and value, commonly referred to as the "7Vs". The capacity to store large volumes of data presents a challenge; while variety encompasses a series of mixed data; velocity denotes the high speed of data processing and veracity points to the level of data accuracy. Furthermore, valence is allied to the complexity of data, while the value is addresses the economic and social cost on application, and variability is largely associated the inconsistencies among all data. The frequency at which big data analytical tools are used were noted by Maryam Ghasemaghaei *et al.* (2016) and further examine the duration and degree of usage. Having such big data, requires complex and diverse analyses methods. Python, R are new analytical tools that can be use to analyze big data suitable with characteristics of big data such as velocity, volume, and variety (Gantz; & Reinsel, 2012). In addition, the application of data analytics can be found in various sectors with in health care, security, business, e-government and market intelligence (Hsinchun Chen, 2012).

2.2. Big data barriers

Many organizations have adopted big data analytics to bring profits to the business. However, organizations are facing many hurdles in the adoption of big data. Kart (2015) noted that only 14% of organizations were successful in adopting big data. A survey of 330 companies in North

Vol. 4, No. 12; 2020

ISSN: 2456-7760

America found that the majority of organizations were not ready for big data adoption (Andrew McAfee & Brynjolfsson, 2012). A number of previous studies have described the barriers to big data adoption. Moktadir *et al.* (2019) based on the Delphi method and data from 5 manufacturing companies in Bangladesh was collected to demonstrate data, technology, investment and organization were related factors that influenced big data adoption in firms. Among these factors, the data-related barrier is the biggest factor influencing big data adoption in firms. Raguseo (2018) used Kruskal-Wallis test and Chi-square test to highlight the benefits and risks of companies. The study distributed 1.962 questionnaires to medium and large French firms. However, only 200 questionnaires were completed. The findings of the study showed some benefits related to transaction, strategic, transformation, and information, whereas, the barriers included technical uncertainty, security, privacy, and uncertainty about receiving benefits. Coleman *et al.* (2016) noticed that SMEs play a fundamental role in the economy of European countries. However, they are facing many challenges in the adoption of big data, whereby, this study showed 14 barriers including knowledge, domain specialists, cultural barriers, in-house data, labor market, business cases, affordable consulting, software market, intuitive software, organizational models, data security, data privacy, and finance.

According to Luna *et al.* (2014) the non-systematic review approach has been used to address the challenges of big data adoption in the health sector in developing countries. Some barriers mentioned in this study such as data capture, infrastructure, organizational changes, integration, privacy, and security. Tabesh *et al.* (2019) identified two main barriers, technology and culture which are related to organizations that apply big data. In addition, Alharthi *et al.* (2017) collected data from 330 company managers in the public sector in North America, to explore the barriers within firms when big data was applied. These barriers included infrastructure, complexity, skills, privacy, and culture.

3. Research methodology

The aim of this research is to provide a summary of barriers and solutions for big data adoption. A systematic review approach was used to conduct this study. A systematic review is rated as practical and goes in-depth and target specific issues (Linchi Kwok, 2017). According to Esther Coren and Fisher (2006) research, this review method provides detailed and clear evidence of research problems to improve the efficiency and reliability of the results. In this study, a systematic review was carried out in two phases including articles selection and articles analysis.

3.1 Articles selection

The process of article selection is presented in Figure 1, indicating the 4 steps of identification, screening, eligibility, and final inclusion. This process has also been used in a few studies recently to select articles (Baig *et al.*, 2019; Eusébio *et al.*, 2020).

In the first step, the identification of the studies was done using a search engine on Science Direct and Google Scholar. The keywords "Big data" and ("Adoption" or "Application") and ("Barriers" or "Challenges") and "Solution" were used in this step to find related articles. Leung (2013) noted that Science Direct and Google Scholar are widely used today as sources for the generation of mass data. By following this step, a total of 326 related articles were downloaded.

Vol. 4, No. 12; 2020

ISSN: 2456-7760

In the second step, three filters were applied; year, type of article, and language. Articles were selected from the last 10 years, from 2011 to 2020. Two types of articles were selected, these included review articles and research articles. A further requirement was that the articles be written in English. The application of these filters found 88 articles that were outdated, written in another language or based on unsuitable article types. For the next screening step, the title, abstract and keywords were evaluated. 129 articles were excluded since they were not related to the challenges of big data application in organizations. As a result of this first screening, 217 articles were rejected. A total of 109 articles remained for the next step.

In the third step, articles were completely read. Many articles cover issues related to big data adoption such as the benefits of big data, the factors that influence big data adoption, big data analysis tools, etc. However, these studies do not address barriers to the adoption of big data nor solutions to big data adoption. Hence, 71 articles were rejected in this step.

In the final step, a total of 38 articles from 2011 to 2020 were used to review the barriers in big data adoption.

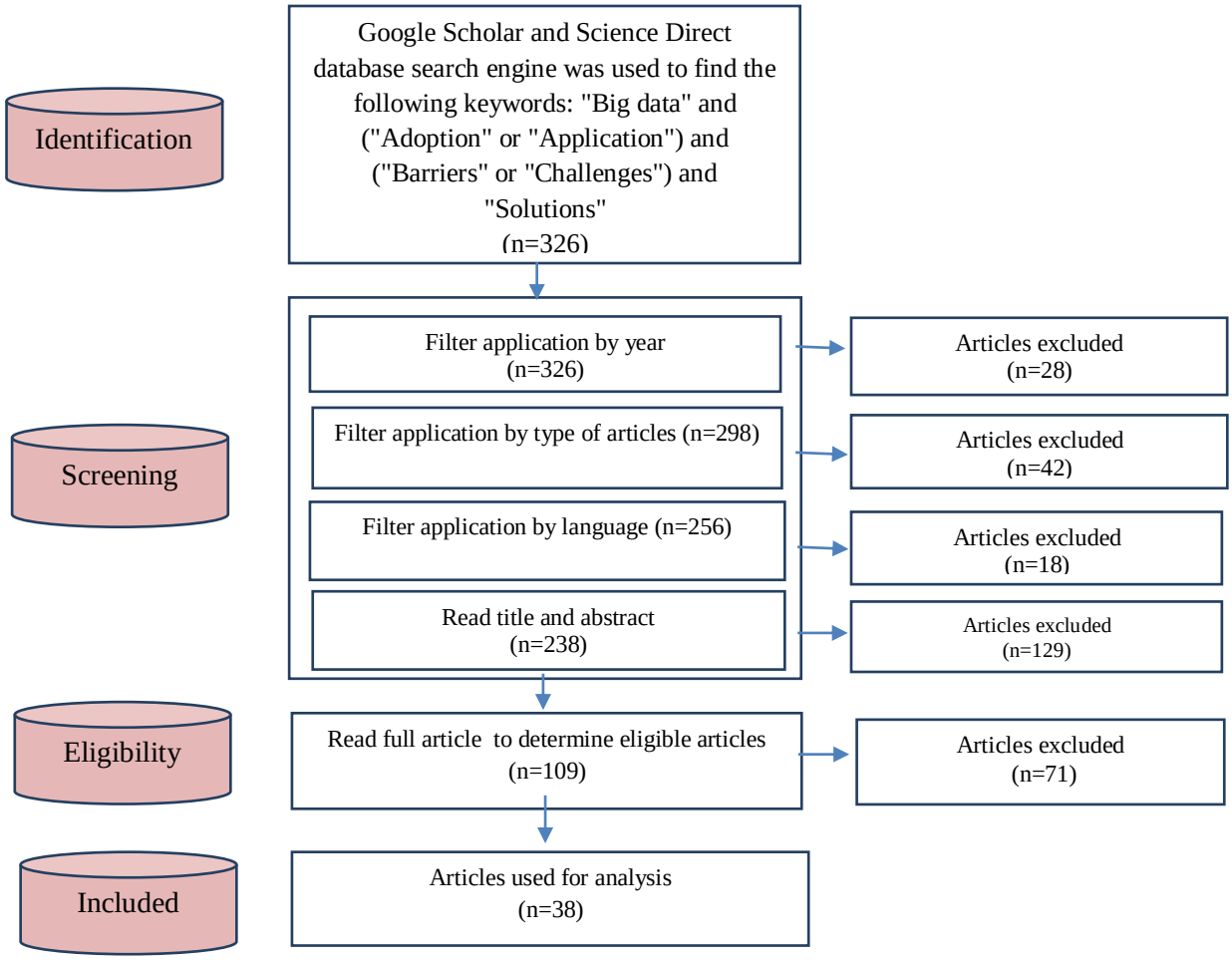

Figure 1. Process of article selection

Vol. 4, No. 12; 2020

ISSN: 2456-7760

Figure 1. Process of article selection

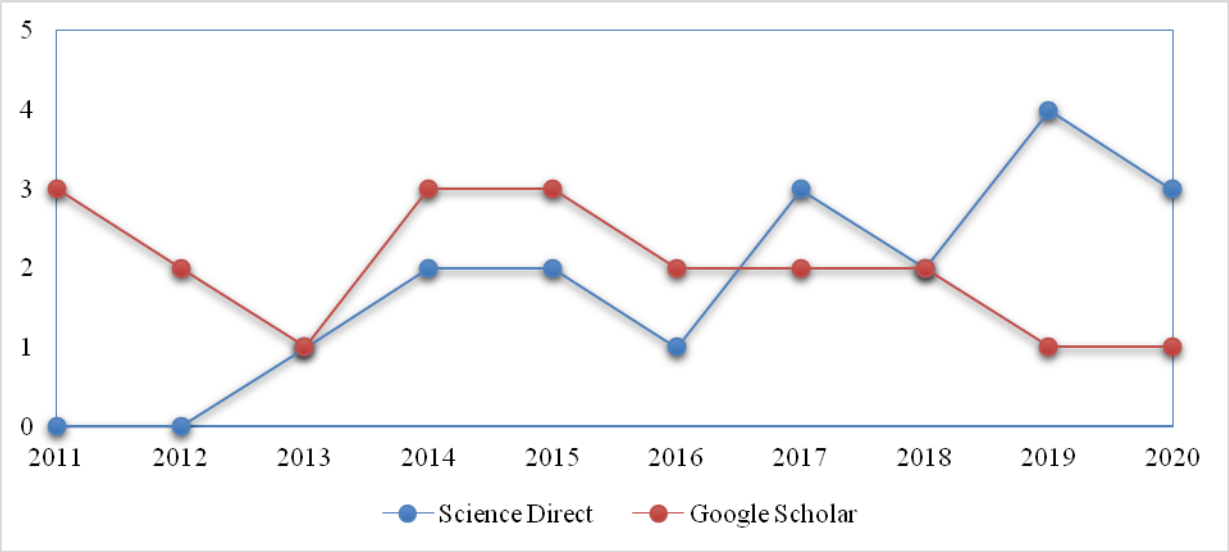

Figure 2. Publication by year

3.2 Articles analysis

After selecting 38 articles related to barriers to big data adoption, we proceeded to code the barriers in each article. For example, Alharthi *et al.* (2017) discussed some challenges to big data adoption, which included infrastructure, complexity, skills, privacy, and culture. From there we identified the barriers to big data adoption as encompassing infrastructure, complexity, skills, privacy, and culture. The barriers of big data adoption in the previous studies were summarized using Excel. NVivo 12 software was used to identify the most frequently used terms in studies involving barriers and solutions in big data applications in previous research.

4. Findings

4.1. Barriers for big data adoption

Barriers to the adoption of big data include not only data and technology factors, but also barriers related to organization, resources, and policies. Therefore, some previous studies have classified barriers in the application of big data into several groups such as data, technology, expertise, and environment (Alalawneh & Alkhatib, 2020; Atreyi Kankanhalli, 2016; Moktadir *et al.*, 2019; Tabesh *et al.*, 2019). Based on previous literature, this research divided the barriers of big data adoption into 4 groups; data, technological, organizational, and environmental with 27 sub-barriers, shown in Table 1, Table 2, Table 3, and Table 4.

Data barriers

Data barriers refers to the issues related to data including privacy, complexity, security, storage, quality, class imbalance, data analysis, data visualization, and performance and scalability. In which, data privacy, data complexity, and data security were the top three barriers that presented in previous research. Data security and data privacy are issues that are particularly concerned

Vol. 4, No. 12; 2020

ISSN: 2456-7760

with the organizations when it comes to big data adoption. Big data includes many personal information and with the rapid increase in its capacity this is considered a valuable data source. This data source can be exploited by unrelated third parties or by cybercriminals (Kshetri, 2014). Privacy issues were not only an issue for small organizations but even large organizations were facing this problem. For example, the data of Facebook's user has been exploited by third parties. This caused much trouble for the organization and as a result Mark Zuckerberg CEO was questioned for more than 10 hours before US senators on this issue. Big data collected from many different sources and formats are characterized as text documents, SMS, images, emails, videos, audio, and messages. Therefore, the complex structure of big data is a hurdle for organizations applying big data (Alharthi *et al.*, 2017). Moreover, the problem of imbalance between classes in data sets is a problem of many organizations recently. This can lead to erroneous predictions in the analysis results (Jofrey L. Leevy, 2018; Rendón *et al.*, 2020).

Table 1. Data barriers affecting big data adoption

Barrier	Sub-barriers	References
Data	Data privacy	(Alharthi *et al.*, 2017; Baig *et al.*, 2019; Bala M. Balachandran & Prasad, 2017; Coleman *et al.*, 2016; Cumbley & Church, 2013; Douglas, 2013; Fatima-Zahra Benjelloun *et al.*, 2015; Le & Liaw, 2017; Luna *et al.*, 2014; Malaka & Brown, 2015a, 2015b; Moktadir *et al.*, 2019; Raguseo, 2018; Shukla & Mattar, 2019; Sivarajah *et al.*, 2017; Sun *et al.*, 2016; Surbakti *et al.*, 2020; Vassakis *et al.*, 2018; Yadegaridehkordi *et al.*, 2018; Yang *et al.*, 2016)
	Data complexity	(Alharthi *et al.*, 2017; Baig *et al.*, 2019; C.L.Philip Chen & Chun-YangZhang, 2014; Douglas, 2013; Fallik, 2014; Jin *et al.*, 2015; Johnson, 2012; Luna *et al.*, 2014; Malaka & Brown, 2015a; Shukla & Mattar, 2019; Sivarajah *et al.*, 2017; Surbakti *et al.*, 2020; Yadegaridehkordi *et al.*, 2018)
	Data security	(Baig *et al.*, 2019; Bala M. Balachandran & Prasad, 2017; Fatima-Zahra Benjelloun *et al.*, 2015; Fatima-Zahra Benjelloun & Lahcen, 2015; Ghasemaghaei, 2020; Le & Liaw, 2017; Moktadir *et al.*, 2019; Sun *et al.*, 2016; Surbakti *et al.*, 2020; Yadegaridehkordi *et al.*, 2018; Yang *et al.*, 2016)
	Data quality	(Bala M. Balachandran & Prasad, 2017; Moktadir *et al.*, 2019; Surbakti *et al.*, 2020; Yadegaridehkordi *et al.*, 2018; Yang *et al.*, 2016)
	Data storage	(Bala M. Balachandran & Prasad, 2017; C.L.Philip Chen & Chun-YangZhang, 2014; Jianqing Fan, 2014; Yang *et al.*, 2016)
	Class imbalance	(Han *et al.*, 2019; Jofrey L. Leevy, 2018; Rendón *et al.*, 2020)
	Data analysis	(C.L.Philip Chen & Zhang, 2014)
	Data visualization	(C.L.Philip Chen & Zhang, 2014)
	Performance and scalability	(Malaka & Brown, 2015b)

Vol. 4, No. 12; 2020

ISSN: 2456-7760

Technological barriers

The challenge of technology highlights the infrastructural problems, lack of skills, financial limitations, and computational complexity of the organizations. Infrastructure refers to the elements of hardware, software, and network system. This is a key factors for organizations to adopt big data. However, the organizations' infrastructure unable to meet the requirements of big data analysis (Alharthi *et al.*, 2017; Trelles *et al.*, 2011). Analyzing big data is a complex process that requires the application of new analytical tools (Sivarajah *et al.*, 2017). Moreover, the lack of specialists capable of analyzing big data is a major challenge for businesses today. Jeanne W. Ross (2013) showed that the reason why organizations fail to deploy big data is because there is a lack of skills about the analysis process. In additional, applying big data requires businesses to have capital investment for suitable infrastructure (Moktadir *et al.*, 2019). Although the choices of information technologies are increasing, the investment costs of applying big data are still high (Sivarajah *et al.*, 2017). Therefore, this is also a barrier for organizations adopting big data.

Table 2. Technological barriers affecting big data adoption

Barrier	Sub-barriers	References
Technology	Infrastructure	(Alalawneh & Alkhatib, 2020; Alharthi *et al.*, 2017; Baig *et al.*, 2019; Coleman *et al.*, 2016; Luna *et al.*, 2014; Malaka & Brown, 2015a, 2015b; Moktadir *et al.*, 2019; Raguseo, 2018; Shukla & Mattar, 2019; Surbakti *et al.*, 2020; Tabesh *et al.*, 2019; Trelles *et al.*, 2011)
	Skills	(Alalawneh & Alkhatib, 2020; Alharthi *et al.*, 2017; Douglas, 2013; Dremel, 2017; Luna *et al.*, 2014; Malaka & Brown, 2015a, 2015b; Raguseo, 2018; Shukla & Mattar, 2019; Vassakis *et al.*, 2018)
	Cost	(Alalawneh & Alkhatib, 2020; Bala M. Balachandran & Prasad, 2017; Coleman *et al.*, 2016; Moktadir *et al.*, 2019; Shukla & Mattar, 2019; Sivarajah *et al.*, 2017)
	Computational complexity	(Jianqing Fan, 2014; Jin *et al.*, 2015)
	Intuitive software	(Coleman *et al.*, 2016)
	System complexity	(Jin *et al.*, 2015)

Organizational barriers

Organizational barriers refer to factors related to organizational culture, knowledge sharing, understanding, time constraints, uncertainty about benefits, management, business strategy, and business sector. In which, barriers to organizational culture and knowledge sharing are the two most discussed barriers in many previous studies. Gupta and George (2016) defined a data-driven culture as "the extent to which organizational members (including top-level executives, middle managers, and lower-level employees) make decisions based on the insights extracted from data". According to Jeanne W. Ross (2013), lack of data-driven culture cause several

Vol. 4, No. 12; 2020

ISSN: 2456-7760

organizations to be unsuccessful in adopting big data. The majority of leaders of companies make decisions based on their own practical experience rather than on the results of data analysis (Andrew McAfee & Brynjolfsson, 2012). Many businesses do not understand how to analyze big data analysis and they are unaware of the benefits big data has can have on their businesses (LaValle & N., 2011). Moreover, organizations are concerned about data security and implying that they hesitate to share data between organizations, between organizations and customers. Therefore, this is also a significant barrier for businesses when implementing big data.

Table 3. Organizational barriers affecting big data adoption

Barrier	Sub-barriers	References
Organization	Culture	(Alalawneh & Alkhatib, 2020; Alharthi *et al.*, 2017; Andrew McAfee & Brynjolfsson, 2012; Baig *et al.*, 2019; Coleman *et al.*, 2016; Dremel, 2017; LaValle & N., 2011; Luna *et al.*, 2014; Sun *et al.*, 2016; Tabesh *et al.*, 2019; Vassakis *et al.*, 2018)
	Knowledge Sharing	(Dremel, 2017; Shukla & Mattar, 2019; Sivarajah *et al.*, 2017)
	Understanding	(Coleman *et al.*, 2016; Tabesh *et al.*, 2019)
	Time constraints	(Malaka & Brown, 2015a, 2015b)
	Uncertainty about benefits	(Raguseo, 2018)
	Management	(Coleman *et al.*, 2016)
	Business strategy	(Sun *et al.*, 2016)
	Business sector	(Alalawneh & Alkhatib, 2020)

Environmental barriers

Environment barriers refers to factors outside the organization that have an impact on the organization's big data application. Lack of policies, training facilities, research facilities, and software market are some of the factors mentioned in this category. Lack of government legal environment policies, and data management policies are barriers to big data adoption (Wixom, 2014). Moreover, training institutions for information technology human resources as well as research institutions and development of analytical tools are limited because they requires the necessary capital investments. This leads to difficulties in improving employees' big data analysis skills, as well as difficulty in finding big data analytics tools for organizations when they apply big data. In additional, the lack of control of the software market leads to many big data analysis software and tools appearing on the market. This makes it difficult for the organization to choose a tool of suitable quality, while ensuring the best value for money. These barriers are described in some previous studies (Coleman *et al.*, 2016; Moktadir *et al.*, 2019).

Vol. 4, No. 12; 2020

ISSN: 2456-7760

Table 4. Environmental barriers affecting big data adoption

Barrier	Sub-barriers	References
Environment	Policies	(Moktadir *et al.*, 2019; Russom, 2011; Wixom, 2014)
	Training facilities	(Malaka & Brown, 2015b; Moktadir *et al.*, 2019)
	Facilities to develop BDA tools	(Moktadir *et al.*, 2019)
	Software market	(Coleman *et al.*, 2016)

Among the 4 groups of barriers affecting the application of big data, there were 31 articles that noted data-related barriers, 19 articles mentioned challenges concerning technology, 17 articles discussed organizational barriers, and 5 articles presented environmental barriers. This shows that data-related factors were the biggest challenges that organizations considered when they adopted big data. Some previous research showed that the data barrier was the biggest barrier that affected the decision to adopt big data in organizations (C.L.Philip Chen & Chun-YangZhang, 2014; Jin *et al.*, 2015; Moktadir *et al.*, 2019). Within the 4 main barriers, security, complexity, privacy, infrastructure, and organizational culture were the most commonly mentioned in previous research (Fatima-Zahra Benjelloun & Lahcen, 2015; Jin *et al.*, 2015; Luna *et al.*, 2014). The volume of big data has increased rapidly. Therefore, organizations applying big data need to update their knowledge of big data and new tools that can solve the big data analysis problems they are facing.

Based on the frequency of each word in the abstracts of 38 articles in the study, the word clouds were generated by NVivo 12 software in Figure 3. The word clouds show that the higher the occurrence of a word, the larger its corresponding font. This Figure illustrates that keywords related to the topic of this study (big data, challenges, barriers, application) show up with the largest frequency. Next, the three barriers that appear significantly in the figure are privacy, security, and complexity. These results show that these are the barriers that organizations are most concerned about when they adopt big data.

Figure 3. Word clouds according to abstracts in previous research

Vol. 4, No. 12; 2020

ISSN: 2456-7760

4.2. Solutions/Recommendations for big data adoption

Big data is advantageous for the improvement and development of organizations. However, as outlined above, organizations face many dilemmas when it comes to adopting big data. This section covers some of the solutions that can help organizations deal with problems in big data adoption (Figure 4).

In solving data related issues, Tabesh *et al.* (2019) suggested that "Assign dedicated data analytics teams and provide them with resource, data access, and bureaucratic immunity". Moreover, organizations need to choose the right tools to ensure data security during the transition and to ensure that complex data sources can be analyzed. Van Rijmenam (2014) suggested that Map Reduce and Hadoop are tools that can be used to store, manage, and analyze data efficiently. According to Imane El Alaouia and Gahi (2020), several solutions should be considered applicable to addressing the security issue such as threat detection, network security assessment, scalability, and encryption. Furthermore, legal authorities need to adopt policies to protect personal data (Schadt, 2012). This will minimize the unauthorized exploitation and use of personal data. Random Over-Sampling (ROS) and Synthetic Minority Over-sampling Technique (SMOTE) methods are currently commonly applied methods to solve the problem of imbalances between classes in large datasets (Rendón *et al.*, 2020).

For the technology barrier, the first solution to successfully applying big data is to establish financial support that can be used for investing in the infrastructure, tools, and human resource development. According to Victoria L. Crittendena and Crittendenb (2008) the firm's supportive certainty is a prerequisite for the successful adoption of new technologies. Organizations should use infrastructure as a service and open source software to maintain financial security (Luna *et al.*, 2014). Organizations can purchase cloud storage services and big data analytics tools from vendors like Google and Amazon. For example, Hadoop, MapReduce, In-Memory DB, and NoSQL are some tools that organizations can be used analyze big data (C.L.Philip Chen & Chun-YangZhang, 2014). Managers should encourage their staff to take big data analysis courses to improve skills related to statistics, analysis and data visualization. To do this, organizations should cooperate with training institutions to improve their employees' skills in big data analysis (Miller, 2014; Van Rijmenam, 2014). Moreover, the organization should have policies to attract experts in the field of information technology. For example, organizations should create a professional working environment, with salaries appropriate to the required level of professional expertise. These help organizations to tackle the lack of human resources that are needed for analyzing big data. However, to have a budget that attracts experts, organizations need to build a budget-balancing strategy from the start. If organizations are not financially ready, they can apply for assistance from information technology projects or support from the government.

Vol. 4, No. 12; 2020

ISSN: 2456-7760

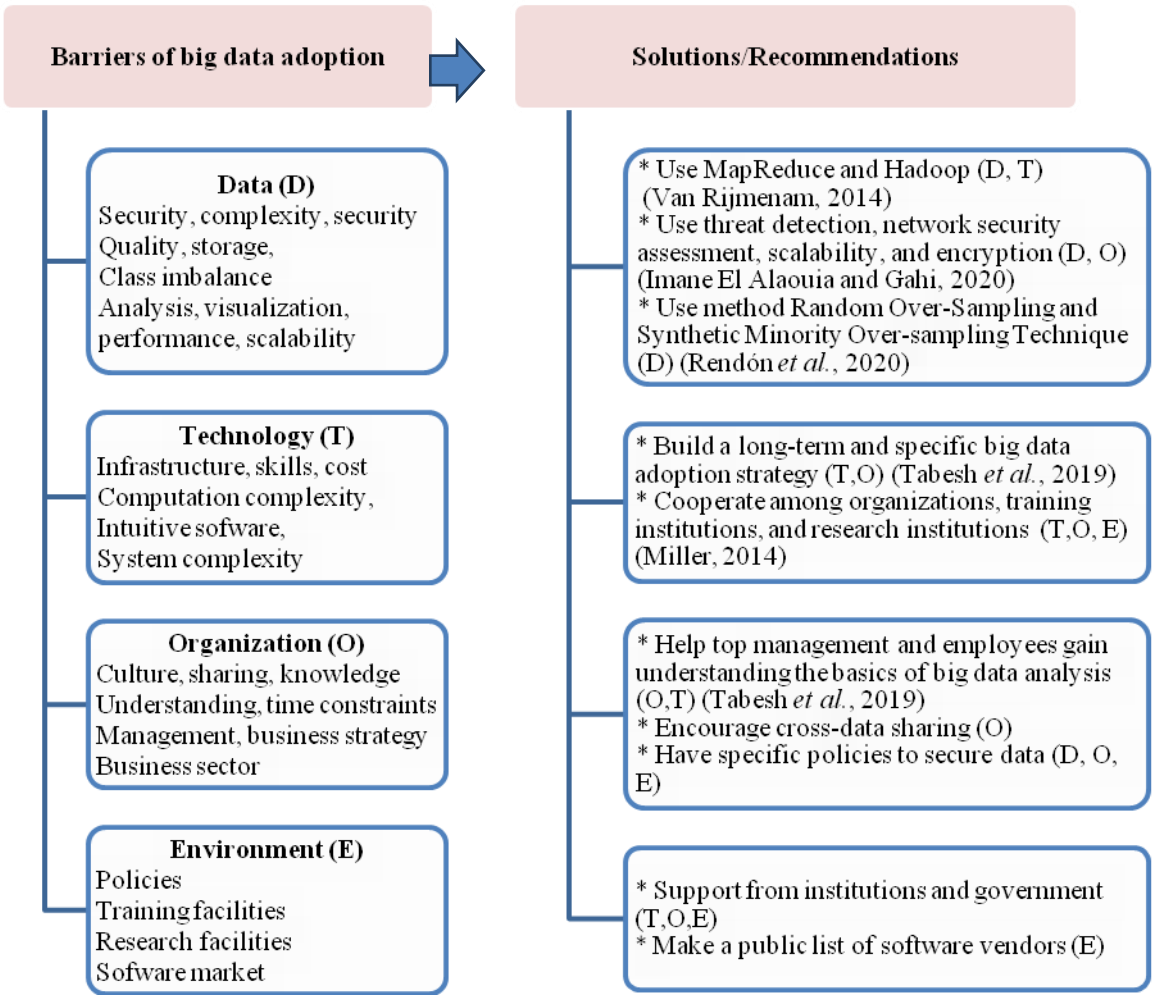

Figure 4. Barriers and solutions/Recommendation for big data adoption

** Note: Some solutions can be applied to multiple barriers. For example, the solution that helps top management and employees gain understanding of the basics of big data analysis can address the barriers of lack of skills and data-driven culture.*

The third recommendation relates to the organization barrier. It is necessary to change the leadership's mindset in decision making. How leaders understand the implications of making decisions based on the results of data analysis is of utmost importance as this helps to improve data-driven culture in organizations. Top management should be encouraged to participate in big data training courses to understand the features, benefits, and processes of big data analysis (Tabesh *et al.*, 2019). Training based on big data knowledge and processing skills, makes an important contribution to helping organizations deal with the lack of data-driven culture. Organizations should cooperate with training institutions such as universities and science and technology research centers to train staff about big data. The study of Miller (2014) showed that students in some universities are trained in the skills necessary for big data analysis.

Vol. 4, No. 12; 2020

ISSN: 2456-7760

Additionally, government and companies should rise useful policies to help ensure data security in the information sharing process (Luna *et al.*, 2014; Moktadir *et al.*, 2019). For example, Europe General Data Protection Regulation. The increase in data protection laws will help individuals and organizations feel secure in sharing data.

To address environmental barriers, it is necessary to build more big data analytical skill training facilities and a research facility to develop big data analysis tools. This requires capital as well as support from the government and other organizations (Moktadir *et al.*, 2019). Many countries have established organizations or projects to support enterprises in applying technological innovation in business fields. For example, the National Sciences and Engineering Research Council of Canada has implemented many projects supporting big data analysis application. In Singapore, the government established a Risk Assessment and Horizon Scanning program with the goal of performing big data analysis in different fields. In Japan, since 2005, the government has had projects working with universities in the research and analysis of big data. These projects also focus on investment in developing infrastructure to ensure suitable conditions for applying big data analysis (Zhong *et al.*, 2016). At the same time, authorities need to enforce policies to control the software market. For example, the government should make a public list of software vendors and big data analysis tools.

Implementing big data in organizations faces many barriers. Therefore, it is necessary for organizations to choose a cycle for sustainable management in big data application. Sustainability management uses new methods, products and organizational procedures to solve existing sustainability issues in a cost effective and preferably profitable way. Attracting new customers by replacing old processes and methods with new alternatives that are proven to be more sustainable then renders the original forms obsolete (Schaltegger, 2013). Since 1996, the Cross-industry Standard Process for Data Mining (CRISP-DM) model has been widely used by professionals in big data application projects. The model is implemented in 6 steps which are Business understanding, Data understanding, Data preparation, Modeling, Evaluation, and Deployment. This model solved the difficulties of applying big data analysis. However, this model did not mention project management activities (Shearer, 2000). In addition, with the strong development of science and technology, big data sources are constantly increasing. Therefore, the steps in the model also need to be updated to address the challenges of applying big data. This study suggests that organizations should adopt big data in a five-step cycle of sustainable management (Figure 5). Firstly, the organizations conduct an assessment of the current state of the organization, including factors related to its data resources, financial resources, information technology infrastructure, and human resources. Second step, organizations point out what are the barriers to big data adoption. The next step is to find solutions to the current barriers that businesses face. In the fourth step, businesses, after finding solutions to their problems will adopt big data. From the big data analysis results generated, businesses build appropriate business strategies. after these strategies have been applied the organization once again assesses it's situation and the cycle is repeated.

Vol. 4, No. 12; 2020

ISSN: 2456-7760

Figure 5. Cycle of sustainable management for big data adoption

5. Managerial Implications

The research shows the barriers that influence the organization's adoption of big data. These factors will be useful for managers to make decisions about applying big data in their enterprises. From four main barriers (data, technology, organization, and environment), managers can identify the big challenges affecting the decision to adopt big data. This study proposes recommendations and a cycle of sustainable management that can help organizations to solve the problems that they encounter when applying big data. Hence, they can construct a more strategic plan before making a decision to adopt big data. Providers of big data analysis tools are also aware of the factors that businesses face when deciding to adopt big data. Therefore, they can establish strategies to develop tools, hardware, software, etc that suit the needs of their customers. This study is also beneficial for training institutions and research institutions for applying big data analysis to build future research training strategies.

6. Conclusions and Limitations

Big data adoption promotes many benefits to organizations by providing better services, strengthening customer relations, upgrading business models, innovating business opportunities, boosting operational efficiency, and establishing competitive advantage. Hence, organizations that implement the use of big data will often see rapid growth and competitive advantages for their businesses. However, there are many hurdles that organizations face when they implement big data. Based on the systematic review method and collected articles from Google Scholar and Science Direct, the study provides an overview of four main barriers groups for big data adoption including data, technology, organization, and the environment. Among these barriers, data barriers are the biggest challenge for organizations. Specifically, security, complexity, and privacy are the most common barriers that organizations consider when they apply big data. On account of this, some solutions were proposed to help organizations solve the problems of big data adoption and a cycle of sustainable management for big data adoption was suggested.

Vol. 4, No. 12; 2020

ISSN: 2456-7760

In this study, two limitations were reported. Firstly, the study summarizes the barriers affecting the application of big data. However, each sub-barrier factor was not analyzed in depth. The future research should only focus on one barrier (data or technology or organization or environment). Therefore, the sub-barriers for each of these main barriers can be analyzed in-depth. Secondly, the articles were collected from two sources, Google Scholar and Science Direct, therefore, articles on the same topic from other sources that were not selected for review. In the future, it is necessary to have studies from diverse data sources such as Springer Link, Taylor & Francis, Emerald insight, AIS Electronic Library, IEEE Xplore.

Acknowledgements

Authors would like to thank Taiwan government, Faculty of Economic and Rural Development at Thai Nguyen University of Agriculture and Forestry, Department of Tropical Agriculture and International Cooperation, National Pingtung University of Science and Technology for all supporting to conduct this study.

References

Alalawneh, A. A. F., & Alkhatib, S. F. (2020). The barriers to big data adoption in developing economies. The Electronic Journal of Information Systems in Developing Countries. doi:10.1002/isd2.12151

Alharthi, A., Krotov, V., & Bowman, M. (2017). Addressing barriers to big data. Business Horizons, 60(3), 285-292. doi:10.1016/j.bushor.2017.01.002

Andrew McAfee, & Brynjolfsson, E. (2012). Big data: The management revolution. Harvard Business Review, 90(10), 60-68.

Andrew McAfee, & Brynjolfsson, E. (2012). Big data: The management revolution Harvard Business Review, 90, 60-68.

Atreyi Kankanhalli, J. H., Sharon Tan, Gordon Gao. (2016). Big data and analytics in healthcare: Introduction to the special section. Information Systems Frontiers, 18(2), 233-235.

Baig, M. I., Shuib, L., & Yadegaridehkordi, E. (2019). Big data adoption: State of the art and research challenges. Information Processing & Management, 56(6), 1-18. doi:10.1016/j.ipm.2019.102095

Bala M. Balachandran, & Prasad, S. (2017). Challenges and Benefits of Deploying Big Data Analytics in the Cloud for Business Intelligence Procedia Computer Science 112, 1112–1122.

C.L.Philip Chen, & Chun-YangZhang. (2014). Data-intensive applications, challenges, techniques and technologies: A survey on Big Data. Information Sciences, 275, 314-347.

C.L.Philip Chen, & Zhang, C.-Y. (2014). Data-intensive applications, challenges, techniques and technologies: A survey on Big Data. Information Sciences, 275, 314-347. doi:10.1016/j.ins.2014.01.015

Vol. 4, No. 12; 2020

ISSN: 2456-7760

Coleman, S., Göb, R., Manco, G., Pievatolo, A., Tort-Martorell, X., & Reis, M. S. (2016). How Can SMEs Benefit from Big Data? Challenges and a Path Forward. Quality and Reliability Engineering International, 32(6), 2151-2164. doi:10.1002/qre.2008

Cumbley, R., & Church, P. (2013). Is "Big Data" creepy? Computer Law & Security Review, 29(5), 601-609. doi:10.1016/j.clsr.2013.07.007

Douglas, M. (2013). Big data raises big questions. Government Technology, 26(4), 12-16.

Dremel, C. (2017). Barriers to the Adoption of Big Data Analytics in the Automotive Sector Twenty-third Americas Conference on Information Systems, Boston, 1-10.

Esther Coren, & Fisher, M. (2006). The conduct of systematic research reviews for SCIE knowledge reviews. London: Social Care Institute for Excellence.

Eusébio, C., Carneiro, M. J., Madaleno, M., Robaina, M., Rodrigues, V., Russo, M., . . . Monteiro, A. (2020). The impact of air quality on tourism: a systematic literature review. Journal of Tourism Futures, ahead-of-print(ahead-of-print). doi:10.1108/jtf-06-2019-0049

Fallik, D. (2014). For big data, big questions remain. Health Affairs (Millwood), 33(7), 1111-1114. doi:10.1377/hlthaff.2014.0522

Fatima-Zahra Benjelloun, Ayoub Ait Lahcen, & Belfkih, S. (2015). An Overview of Big Data Opportunities, Applications and Tools. In: Intelligent Systems and Computer Vision (ISCV), IEEE, 1-6.

Fatima-Zahra Benjelloun, & Lahcen, A. A. (2015). Big Data Security: Challenges, Recommendations and Solutions. Handbook of Research on Security Considerations in Cloud Computing. IGI Global, 301-313.

Gantz; J., & Reinsel, D. (2012). The digital universe in 2020: Big data, bigger digital shadows, and biggest growth in the far east. IDC iView: IDC Analyze the future 2007, 1-16.

Ghasemaghaei, M. (2020). The role of positive and negative valence factors on the impact of bigness of data on big data analytics usage. International Journal of Information Management, 50, 395-404. doi:10.1016/j.ijinfomgt.2018.12.011

Günther, W. A., Rezazade Mehrizi, M. H., Huysman, M., & Feldberg, F. (2017). Debating big data: A literature review on realizing value from big data. The Journal of Strategic Information Systems, 26(3), 191-209. doi:10.1016/j.jsis.2017.07.003

Gupta, M., & George, J. F. (2016). Toward the development of a big data analytics capability. Information & Management, 53(8), 1049-1064. doi:10.1016/j.im.2016.07.004

Han, W., Huang, Z., Li, S., & Jia, Y. (2019). Distribution-Sensitive Unbalanced Data Oversampling Method for Medical Diagnosis. J Med Syst, 43(2), 39. doi:10.1007/s10916-018-1154-8

Hsinchun Chen, R. H. L. C. a. V. C. S. (2012). Business Intelligence and Analytics: From Big Data to Big Impact. MIS Quarterly, 36, 1165-1188.

Vol. 4, No. 12; 2020

ISSN: 2456-7760

Imane El Alaouia, & Gahi, Y. (2020). Network Security Strategies in Big Data Context. Procedia Computer Science, 175, 730-736.

Jeanne W. Ross, C. M. B., Anne Quaadgras. (2013). You may not need big data after all. Harvard Business Review, 91, 90-98.

Jianqing Fan, F. H., Han Liu. (2014). Challenges of Big Data analysis. NSR National Science Review, 1.

Jin, X., Wah, B. W., Cheng, X., & Wang, Y. (2015). Significance and Challenges of Big Data Research. Big Data Research, 2(2), 59-64. doi:10.1016/j.bdr.2015.01.006

Jofrey L. Leevy, T. M. K., Richard A. Bauder, Naeem Seliya. (2018). A survey on addressing high‐class imbalance in big data. Journal of Big Data, 5(42), 1-30. doi:10.1186/s40537‐018‐0151‐6

Johnson, J. E. (2012). Big data + big analytics = big opportunity. Financial Executive, 28(6), 50-53.

Kshetri, N. (2014). Big Data's impact on privacy, security and consumer welfare. Policy, 38, 1134-1145.

LaValle, S., Lesser, E., Shockley, R., Hopkins, M. S., & Kruschwitz,, & N. (2011). Big data, analytics, and the path from insights to value. MIT Sloan Management Review, 52, 21-32.

Le, & Liaw, S.-Y. (2017). Effects of Pros and Cons of Applying Big Data Analytics to Consumers' Responses in an E-Commerce Context. Sustainability, 9(5). doi:10.3390/su9050798

Leung, D., Law, R., van Hoof, H., & Buhalis, D. . (2013). Social media in tourism and hospitality: A literature review. Journal of Travel & Tourism Marketing, 30(1), 3-22.

Linchi Kwok, K. L. X., Tori Richards. (2017). Thematic framework of online review research. Thematic framework of online review research. International Journal of

Contemporary Hospitality Management, 29(1), 307-354.

Luna, D., Mayan, J. C., Garcia, M. J., Almerares, A. A., & Househ, M. (2014). Challenges and potential solutions for big data implementations in developing countries. Yearbook of medical informatics, 9, 36-41. doi:10.15265/IY-2014-0012

Malaka, I., & Brown, I. (2015a). Challenges to the organisational adoption of big data analytics. In Proceedings of the 2015 annual research conference on South African institute of computer scientists and information technologists – SAICSIT, 15, 1-9.

Malaka, I., & Brown, I. (2015b). Challenges to the organisational adoption of big data analytics: A case study in the South African telecommunications industry. Proceedings of the 2015 annual research conference on South African institute of computer scientists and information technologists, tellenbosch, South Africa: ACM, New York., 1-9.

Mandeep Kaur Saggi, & Jain, S. (2018). A survey towards an integration of big data analytics to big insights for value-creation. Information Processing & Management, 54, 758-790.

Vol. 4, No. 12; 2020

ISSN: 2456-7760

Maryam Ghasemaghaei, Sepideh Ebrahimi, & Hassanein, K. (2016). Increasing firm agility through the use of data analytics: The role of fit. Decision support systems. International Conference on Information Systems 2016.

Miller, S. (2014). Collaborative Approaches Needed to Close the Big Data Skills Gap. Journal of Organization Design, 3(1), 26-30.

Min Chen, Shiwen Mao, & Liu, Y. (2014). Big data: A survey. Mobile Networks and Applications 19(2), 171-209.

Moktadir, M. A., Ali, S. M., Paul, S. K., & Shukla, N. (2019). Barriers to big data analytics in manufacturing supply chains: A case study from Bangladesh. Computers & Industrial Engineering, 128, 1063-1075. doi:10.1016/j.cie.2018.04.013

Muhammad Habibur Rehman, IbrarYaqoob, KhaledSalah, Muhamma Imran, Prem Prakash Jayaraman, & CharithPerera. (2019). The role of big data analytics in industrial Internet of Things. Future Generation Computer Systems, 99, 247-259. doi:10.1016/j.future.2019.04.020

Raguseo, E. (2018). Big data technologies: An empirical investigation on their adoption, benefits and risks for companies. International Journal of Information Management, 38(1), 187-195. doi:10.1016/j.ijinfomgt.2017.07.008

Rendón, E., Alejo, R., Castorena, C., Isidro-Ortega, F. J., & Granda-Gutiérrez, E. E. (2020). Data Sampling Methods to Deal With the Big Data Multi-Class Imbalance Problem. Applied Sciences, 10(4). doi:10.3390/app10041276

Russom, P. (2011). Big data analytics. TDWI Best Practices Report, Fourth Quarter, 19(4), 1-34.

Schadt, E. E. (2012). The changing privacy landscape in the era of big data. Molecular Systems Biology. Molecular Systems Biology, 8(1), 1-3.

Schaltegger, S. (2013). Sustainability Management. In S. O. Idowu, N. Capaldi, L. Zu, & A. D. Gupta (Eds.), Encyclopedia of Corporate Social Responsibility (pp. 2384-2388). Berlin, Heidelberg: Springer Berlin Heidelberg.

Shearer, C. (2000). The CRISP-DM model: the new blueprint for data mining. Journal of Data Warehousing, 5, 13-22.

Shukla, M., & Mattar, L. (2019). Next generation smart sustainable auditing systems using Big Data Analytics: Understanding the interaction of critical barriers. Computers & Industrial Engineering, 128, 1015-1026. doi:10.1016/j.cie.2018.04.055

Sivarajah, U., Kamal, M. M., Irani, Z., & Weerakkody, V. (2017). Critical analysis of Big Data challenges and analytical methods. Journal of Business Research, 70, 263-286. doi:10.1016/j.jbusres.2016.08.001

Sun, S., Cegielski, C. G., Jia, L., & Hall, D. J. (2016). Understanding the Factors Affecting the Organizational Adoption of Big Data. Journal of Computer Information Systems, 58(3), 193-203. doi:10.1080/08874417.2016.1222891

Vol. 4, No. 12; 2020

ISSN: 2456-7760

Surbakti, F. P. S., Wang, W., Indulska, M., & Sadiq, S. (2020). Factors influencing effective use of big data: A research framework. Information & Management, 57(1). doi:10.1016/j.im.2019.02.001

Tabesh, P., Mousavidin, E., & Hasani, S. (2019). Implementing big data strategies: A managerial perspective. Business Horizons, 62(3), 347-358. doi:10.1016/j.bushor.2019.02.001

Trelles, O., Prins, P., Snir, M., & Jansen, R. C. (2011). Big data, but are we ready? Nature Review Genetics, 12(3), 224. doi:10.1038/nrg2857-c1

Van Rijmenam, M. (2014). Think bigger: Developing a successful big data strategy for your business. New York: AMACOM.

Vassakis, K., Petrakis, E., & Kopanakis, I. (2018). Big Data Analytics: Applications, Prospects and Challenges. In Mobile Big Data (pp. 3-20).

Victoria L. Crittendena, & Crittendenb, W. F. (2008). Building a capable organization: The eight levers of strategy implementation. Business Horizons, 51, 301-309.

Wang, L., Yang, M., Pathan, Z. H., Salam, S., Shahzad, K., & Zeng, J. (2018). Analysis of Influencing Factors of Big Data Adoption in Chinese Enterprises Using DANP Technique. Sustainability, 10(11). doi:10.3390/su10113956

Wixom, B. A., Thilini; Douglas, David; Goul, Michael; Gupta, Babita; Iyer, Lakshmi; Kulkarni, Uday; Mooney, JohnG.; Phillips-Wren, Gloria; and Turetken, Ozgur (2014). The Current State of Business Intelligence in Academia: The Arrival of BigData. Communications of the Association for Information Systems, 34, 1-13.

Yadegaridehkordi, E., Hourmand, M., Nilashi, M., Shuib, L., Ahani, A., & Ibrahim, O. (2018). Influence of big data adoption on manufacturing companies' performance: An integrated DEMATEL-ANFIS approach. Technological Forecasting and Social Change, 137, 199-210. doi:10.1016/j.techfore.2018.07.043

Yang, C., Huang, Q., Li, Z., Liu, K., & Hu, F. (2016). Big Data and cloud computing: innovation opportunities and challenges. International Journal of Digital Earth, 10(1), 13-53. doi:10.1080/17538947.2016.1239771

Yuri Demchenko, P. G., Cees de Laat, Peter Membrey. (2013). Addressing big data issues in scientific data infrastructure. Collaboration technologies and systems (CTS), international conference 48-55.

Zhong, R. Y., Newman, S. T., Huang, G. Q., & Lan, S. (2016). Big Data for supply chain management in the service and manufacturing sectors: Challenges, opportunities, and future perspectives. Computers & Industrial Engineering, 101, 572-591. doi:10.1016/j.cie.2016.07.013