Macrothink Institute™

Business and Economic Research
ISSN 2162-4860
2023, Vol. 13, No. 2

Beyond the Hype of Big Data Analytics Deployment: Conceptualization and Challenges Epistemology

Sharina Tajul Urus

Faculty of Accountancy, Universiti Teknologi MARA, Cawangan Selangor

Kampus Puncak Alam, Selangor, Malaysia

E-mail: sharina675@uitm.edu.my

Intan Waheedah Othman (Corresponding author)

Faculty of Accountancy, Universiti Teknologi MARA, Cawangan Selangor

Kampus Puncak Alam, Selangor, Malaysia

E-mail: waheedah87@uitm.edu.my

Zarinah Abdul Rasit

Faculty of Accountancy, Universiti Teknologi MARA, Cawangan Selangor

Kampus Puncak Alam, Selangor, Malaysia

E-mail: zarinah731@uitm.edu.my

Noraizah Abu Bakar

Faculty of Accountancy, Universiti Teknologi MARA, Cawangan Johor

Kampus Segamat, Johor, Malaysia

E-mail: norai738@uitm.edu.my

Sharifah Nazatul Faiza Syed Mustapha Nazri

Faculty of Accountancy, Universiti Teknologi MARA, Cawangan Johor

Kampus Segamat, Johor, Malaysia

E-mail: shari744@uitm.edu.my

Macrothink Institute™

Business and Economic Research
ISSN 2162-4860
2023, Vol. 13, No. 2

Received: March 14, 2023 Accepted: April 14, 2023 Published: May 25, 2023

doi:10.5296/ber.v13i2.20807 URL: https://doi.org/10.5296/ber.v13i2.20807

Abstract

Businesses, government sectors, academia and society have been flooded with data which nowadays have become valuable economic assets. Data and Big Data Analytics (BDA) are vital for the succession of any organization. Big Data Analytics (BDA) delineates the approaches utilized to examine, process, analyze and expose hidden underlying patterns, interesting relations, and intelligence from huge datasets for different purposes. Despite the growth and widespread use of data analytics, the study on this research area is still at the nascent stage. The scenario is seen particularly for the developing countries like Malaysia. Previous literature has recognized data analytic development and its effect but has not yet provided a comprehensive review. This paper intends to conceptualize BDA manifestation, its application, and its challenges epistemology. This study employs a comprehensive review of past literature to serve the purpose. The findings of this paper will enhance the understanding of BDA conception epistemology (definition and application). This concept paper also intends to shed some light on BDA research areas by identifying the challenges surrounding BDA deployment. From the theoretical point of view, this paper contributes to providing BDA taxonomy based on the application in various industries. From the practical perspective, this paper contributes to BDA research field by identifying the obstacles that need to be managed by the BDA adopter for optimum utilization and decision making. From the government perspective, it contributes to Malaysian national agenda to becoming a leading regional BDA solution hub for all sectors and developed nation by the year 2025.

Keywords: Big data, Big data analytics (BDA), Conceptualization, Challenges, Recommendations

1. Introduction

Industry 4.0, often known as the fourth industrial revolution, is the culmination of technology developments in areas including the Internet of Things (IoT), Artificial Intelligence (AI), Big Data, and Data Analytics. Data and Big Data Analytics (BDA) are becoming extremely important, like the lifeblood of any successful business or organization. As observed from the amount of data being generated today, big data seems to be in full throttle of exponential growth. Businesses, government sectors, academia and society were flooded with data which nowadays have become valuable economic assets. A massive amount of data referred to as “big data” has been generated through the integration of users’ background details and everyday activities in social media has been intensively researched recently. Commonly, big data is defined as a collection of huge data sets that come from various sources with a diversity of types. They have become difficult to process using the traditional data processing (Philip Chen & Zhang, 2014; Raut et al., 2019; Piccarozzi & Aquilani, 2022). Billions of people are using social media platforms and the contents of these social media such as tweets, comments, posts, and reviews contributed to the erosion of unstructured data creation in short

timescales (Ghani et al., 2019; Ishikiriyama & Gomes, 2019).

The term ‘‘big data’’, popularized over the past decade, which received many definitions and interpretations; has given a different meaning to different things and to different people. Statisticians tend to think of ‘‘big’ in terms of size, either many cases or many variables or both. In a wider meaning to the public, ‘‘big’’ also refers to the extent, impact, and mindshare of the phenomenon (Faraway & Augustin, 2018). Big data is a term for a collection of huge sets of production and complex in structure beyond the capability of common spreadsheet programs data, aggressive or conventional information technologies such as Excel, on-hand database management tools or traditional data processing applications to capture, manage, process, and analyze them (Bhat, 2018; Cobb et al., 2018; Ishikiriyama & Gomes, 2019). Big Data definition in finance is classified based on the three properties, namely large size, high dimension, and complex structure (Goldstien, Spat & Ye, 2021).

Big data is meaningless in a vacuum. Its promising value is unlocked only when it is leveraged to drive decision making. Every corporate and organization need an efficient process to change high volumes of fast-moving and divergent data into substantial insights to enable such evidence-based and useful decision making (Gandomi & Haider, 2015; Gökalp et.al, 2022; Naeem et al., 2022). Sivarajah et al. (2017) argued that big data on its own which consists of huge raw data set have not offered valuable insight in its crude form. Businesses need dynamic processes and mechanisms to turn high volumes of structured and unstructured data to analyze the raw data sets if they want to unlock its potential value.

The analysis of such a huge amount of data is called, in general terms, Big Data Analytics (BDA). Analytics in this context refers to the techniques utilized to examine, process, analyze and expose hidden underlying patterns, interesting relations, and intelligence from huge datasets for different purposes. It can be regarded as a sub-process which consists of a combination of multiple information technology-enabled resources with the purpose of discovering knowledge, insight extraction, predicting outcomes and consequently, creating competitive advantage and empowering businesses to support their strategic decision-making (Gökalp et al., 2022; Ishikiriyama & Gomes, 2019; Barbosa et al., 2018; Labrinidis & Jagadish, 2012). A technology like BDA, regarded as a new method to extract patterns from a set of raw information has wrought dynamic changes in the competitive business environment in terms of assisting informed decision-making, innovation upgrades, enhanced productivity, and knowledge generation (Lutfi et al., 2022).

In Malaysia, BDAs has been identified as a major catalyst of change that will lead the country to the forefront of innovation and sustainability under the Eleventh Malaysia Plan that stretched out from the year 2016 till 2020. Hence, some major effort has been taken by the Malaysian government to encourage the deployment of BDA. This includes the setting up of Malaysian Digital Economy Corporation Sdn. Bhd. (MDEC), the holistic, government-owned agency that is responsible to pioneer the transformation of Malaysia’s digital economy. Aligned with the Malaysian inspiration to become a developed nation by the year 2025, the government has identified key digital areas to drive ICT sector. Besides other components such as cloud computing, internet of things (IoT), cybersecurity, artificial

intelligence (AI), Big Data and Analytics have also been identified amongst the important elements that form the nine pillars of the Industrial Revolution 4.0 (IR 4.0).

The big data analytics (BDA) market in Malaysia is expected to grow to US$1.9 billion (about RM7. 85 billion) in 2025, from US$1.1 billion in 2021, according to Malaysia Digital Economy Corp's (MDEC) commissioned study by IDC.17 May 2021. The study noted that the service sector will contribute 64% of total data – driven spending, with the banking and telecommunications sectors contributing nearly a third, MDEC noted in a statement on May 10, 2021. According to the International Data Corporation (IDC, 2017), the Malaysian BDA market is forecasted to reach RM595 million by 2021. Meanwhile, the Malaysian Digital Economy Corporation (an agency under the Ministry of Communications and Multimedia) is on a mission to position Malaysia as the regional hub for BDA in Southeast Asia. The agency receives full government support to encourage all business sectors including the warehouse and logistics industry to adopt BDA technology (MDEC, 2018).

Despite the Malaysian government's inspiration and of the many advantages offered by BDA to the organization's current system and ability to support the national agenda, the adoption rate among the BDA organizations is still low (The Edge Market, 2017), yet Malaysian firms are actively progressing from the ad-hoc stage to the maturity-stage, and subsequently the opportunistic-stage (Wahab et al., 2021). The question is still lingering on why many organizations are not taking advantage of this tool to measure their activities and performance despite its availability for real-time digital data. Besides, the view on why there is a discouraging deployment of big data analytics amongst organizations is worth further investigation.

This paper attempts to explore the BDA conceptualization and manifestation of BDA deployment. The challenges behind BDA adoption are also worth further investigation to offer useful insights of BDA technology adoption. The study will contribute to the understanding of BDA, its manifestation, and how BDA evolves. This concept paper also sheds some light on BDA research areas by identifying the challenges surrounding BDA implementation.

From the theoretical point of view, this paper contributes to providing BDA taxonomy based on the application in various industries. From the practical perspective, this paper contributes to BDA research field by identifying the obstacles that need to be managed by the BDA adopter for optimum utilization and decision making. From the government perspective, it contributes to Malaysian national agenda to becoming a leading regional BDA solution hub for all sectors.

2. Big Data Conceptualization

2.1 Definition of Big Data

The data characteristics have been the biggest challenges. Gupta and Rani (2019) stated that, currently, there is no standardized definition for big data. The constant evolution of big data development causes a debate on defining big data as today's big data may be tomorrow's small data. Different researchers have distinct understandings towards the data characteristics

(Sivarajah et al., 2017). The original and well-known definition is the 3Vs, which characterizes big data as Volume, Variety and Velocity (Chen et al., 2012; Gantz & Reinsel, 2011; Kwon et al., 2014; Laney, 2001; Lin et al., 2020; Shah et al., 2014). Recently, two more additional "Vs" – Veracity and Variability added to the characteristics (Gandomi & Haider, 2015; Mishra et al., 2021; Fosso Wamba et al., 2015). Sivarajah et al. (2017) in their study added Visualization that makes the seventh characteristic of big data.

2.2 Big Data Features

2.2.1 The Three Vs of Big Data

There have been various definitions of Big Data so far. Still, in general, Big Data refers to the voluminous and complex sets of data that almost all conventional data processing software fails to control. As time goes by, Big Data keeps increasing in its size and is commonly characterized by the so-called Vs (usually 3Vs): Volume, Velocity, and Variety.

(1) Volume:

The amount of Big Data has yet to be determined now, and people have kept discussing how voluminous it is to be called Big Data. The size of Big Data is ever-increasing and variable, ranging from terabytes (TB) to exabytes (EB), even up to zettabytes. In brief, its huge size has come as a surprise to us, to the extent that we may not imagine.

(2) Variety:

Big Data contains data coming from various sources with inconsistencies in formats and categories. The kinds of data stored in Big Data grow more diverse over time, including structured (the traditional type), unstructured (texts, videos, audios, images, etc.), or even semi-structured like json or xml files.

(3) Velocity:

Due to its giant size, variety and complexity, Big Data needs to be processed within a short period, usually and expectedly homologous with real-time.

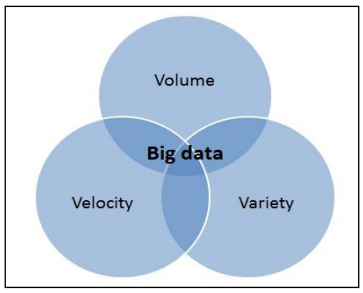

Figure 1. The 3 Vs of Big Data (source: https://bigdataldn.com)

2.2.2 The Four Vs of Big Data

Big data has evolved from the classical 3Vs when researchers extended the characteristics to be 4Vs - Volume, Velocity, Variety, and Variability (Balusamy et al., 2021; Liao et al., 2014). Gantz and Reinsel (2011) introduced Value to highlight the validity and usefulness of big data. Determining the right or required values of the data during data extraction is essential for data analysis (Kaliraj & Devi, 2022). Besides the 3Vs mentioned above, most of the past studies (Deepa et al., 2022; Hajjaji et al., 2021; Jaiswal, 2018; Kostakis & Kargas, 2021) agreed that big data share four main characteristics, referred to as the four V's (Volume, Variety, Veracity and Velocity) (Figure 4 below).

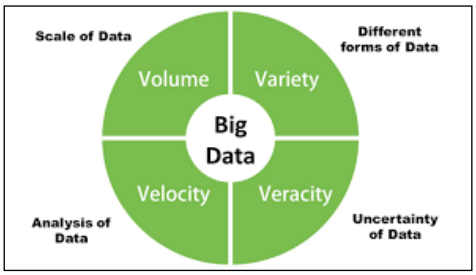

Figure 2. The 4 Vs of Big Data (source: Smith, 2020)

The volume refers to the size and magnitude of data which typically require distributed storage and processing. The data sizes could consist of multiple terabytes, petabytes, or zettabytes of data (Chaudhary & Alam, 2022; Gandomi & Haider, 2015; Inoubli et al., 2018). The variety refers to the fact that big data composed of multiple types of data formats, either it is structured or unstructured such as text, sound, image, multimedia, audio, sensor data and video. Inconsistency of the enormous volume of data is captured in diverse forms and sources such as messages from tweets, blogs, transactional data, scientific data, web data and much more (Aldridge & Avellaneda, 2021; Chen et al., 2012). Big data originality is indicated by the structural heterogeneity of these different forms and quality of data, hence, to comprehend and manage such data is a big challenge (Azeem et al., 2022; Gandomi & Haider, 2015). Veracity is knowing whether the data that is available comes from a credible source and is of utmost importance before deciphering and implementing Big Data for business needs.

2.2.3 The Fifteen Vs of Big Data

Panimalar, Shree and Kathrine (2017) have identified the fifteen characteristics of big data and three new characteristics of big data have been explored further to handle big data efficiently. Other than that, Mishra et al. (2021) as well as Saggi and Jain (2018) also listed up to different other attributes of big data that are somewhat like the ones listed below.

Table 1. The 15 Vs of Big Data (source: Panimalar et al., 2017)

No	Big Data Attributes	Explanation	Description
1	Volume	Size of Data	Quantity of collected and stored data. Data size is in TB
2	Velocity	Speed of Data	The transfer rate of data between source and destination
3	Value	Importance of Data	It represents the business value to be derived from big data
4	Variety	Type of Data	Different types of data like pictures, videos and audio arrive at the receiving end
5	Veracity	Data Quality	Accurate analysis of captured data is virtually worthless if it is not accurate
6	Validity	Data Authenticity	It is defined as to how accurate and correct the data is for its intended use
7	Volatility	Duration of Usefulness	Big data volatility means the stored data and how long is useful to the user
8	Visualization	Data Act/ Data Process	It is a process of representing abstract
9	Virality	Spreading Speed	It is defined as the rate at which the data is broadcast /spread by a user and received by different users for their use
10	Viscosity	Lag of Event	It is a time difference the event occurred and the event being described
11	Variability	Data Differentiatio	Data arrives constantly from different sources and how efficiently it differentiates between noisy data or important data
12	Venue	Different Platform	Various types of data arrived from different sources via different platforms like personnel system and private and public cloud
13	Vocabulary	Data Terminology	Data terminology like data model and data structures
14	Vagueness	Indistinctness of existence in a Data	Vagueness concerns the reality in information that suggested little or no thought about what each might convey
15	Complexity	Correlation of Data	Data comes from different sources, and it is necessary to figure out the changes whether small or large in data with respect to the previously arrived data so that information can be retrieved quickly

3. Big Data Analytics (BDA) Conceptualization

3.1 Definition of Big Data Analytics (BDA)

Analyzing this data can help organizations to develop new products, to improve their efficiency and effectiveness, as well as to make better decisions. Organizations are looking at the current development of technology like BDA to cater to the demand for useful information as well as to remain competitive in the market. Consequently, many organizations are adopting BDA to extract valuable information from big data. BDA is a dynamic process and mechanism to turn high volumes of structured and unstructured data in analyzing these raw data sets to unlock its potential value (Barbosa et al., 2018; Marr, 2022). BDA provides informative insights and new opportunities that lead to smarter business moves, more efficient operations, and higher profits. BDA is warmly and whole-heartedly accepted by developed countries; its world-wide acceptance is still a challenge particularly amongst developing countries despite its popularity amongst them. In the other study by Talaoui et al. (2023), they proposed a relationship between BDA and strategy. They have identified two dominant discourses. Firstly, an input-output discourse that views big data analytics as a computational capability supplementing prospective strategy formulation. Secondly, an entanglement discourse that theorizes big data analytics as a socially constructed agent that

(re)shapes the emergent character of strategy formation.

Big Data Analytics (BDA) can be conceptualized as a suite of data management and analytical techniques for handling very large (from terabytes and exabytes) and complex (from sensor to social media) data. The term big data analytics can be defined as the application of advanced analytic techniques including data mining, statistical analysis, predictive analytics, to name a few on big datasets as new business intelligence practice (Chaudhary & Alam, 2022; Russom, 2011). BDA is also referred to as a computation technique with five characteristics, namely, volume, velocity, variety, veracity, and value which pose challenges in delivering business-critical information to both big and small firms (Ardagna et al., 2021; Gandomi & Haider, 2015).

3.2 Types of Big Data Analytics (BDA)

There are four types of analytics characteristics in big data namely, descriptive, diagnostic, predictive and prescriptive. Figure 3 shows the types of data analytics:

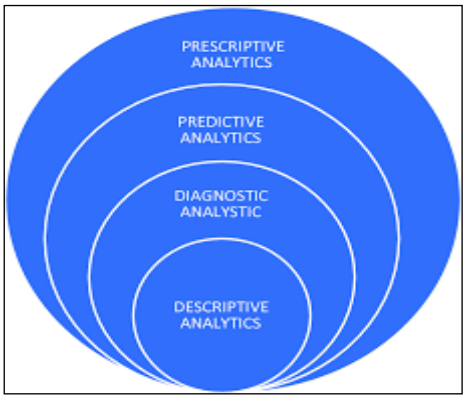

Figure 3. Types of BDA (source: Panimalar et al., 2017)

In data processing, descriptive analytics is the initial phase that provides all the necessary historical or past data needed to provide valuable information. The diagnostic analytics is an improved type of analytics characterized by techniques, such as data discovery, drill-down, data mining and data correlations.

Predictive data analytics suggests how we make predictions about future outcomes using historical data combined with statistical modelling, data mining techniques and machine learning. Companies employ predictive analytics to find patterns in this data to identify risks and opportunities. Lastly, prescriptive data analytics implied uses of the past performance and trends to determine what needs to be done to achieve future goals. Table 2 presents the summary of the types of big data analytics and its characteristics.

Table 2. Summary of types of big data analytics and its characteristics (source: Panimalar et al., 2017)

Types of Big Data Analytics	Characteristics of Big Data Analytics
Descriptive	Based on historical and current data, it is a significant source of insights about what happened in the past and the correlations between various determinants identifying patterns using statistical measures like mean, range, and standard deviation.
Diagnostic	Based on historical data that provide insights about the root-cause of some outcomes of the past.
Predictive	About forecasting and providing an estimation for the probability of a future result, defining opportunities or risks in the future.
Prescriptive	Provide a forecasting of the impact of future actions before they are taken, answering "what might happen" as outcome of the organization action.

Even though there is controversy in definition, big data and big data technologies have made great contributions in improving scientific research (Li et al., 2018; Mészáros & Ho, 2018). Figure 3 shows the overall process of extracting insights from big data that can be broken down into five stages. These five stages form the two main sub-processes: data management and analytics. Data management involves processes and supporting technologies to acquire and store data and to prepare and retrieve it for analysis. Analytics, on the other hand, refers to techniques used to analyze and acquire intelligence from big data. Thus, big data analytics can be viewed as a sub-process in the overall process of 'insight extraction' from big data (Balas et al., 2019; Labrinidis & Jagadish, 2012).

3.3 Application of Big Data and Data Analytics

3.3.1 Overview of BDA Evolvement

BDA has come a long way since its genesis. Yaqoob et al. (2016) summarized the development of big data applications across different eras. Figure 4 below represents the genesis of big data applications that showed the evolvement of big data analytics from the technologies used and the applications. From standalone applications, the users' action is processed by a single processing unit, based on the computation speed of the host machine. Then, desktop computers allow multiple standalone applications to run more efficiently and handle much more data. The introduction of Internet has given rise to simple web applications such as Google Docs, Meebo, and Wobzip that can be used remotely, allowing better access to data and the use of cloud computing technology.

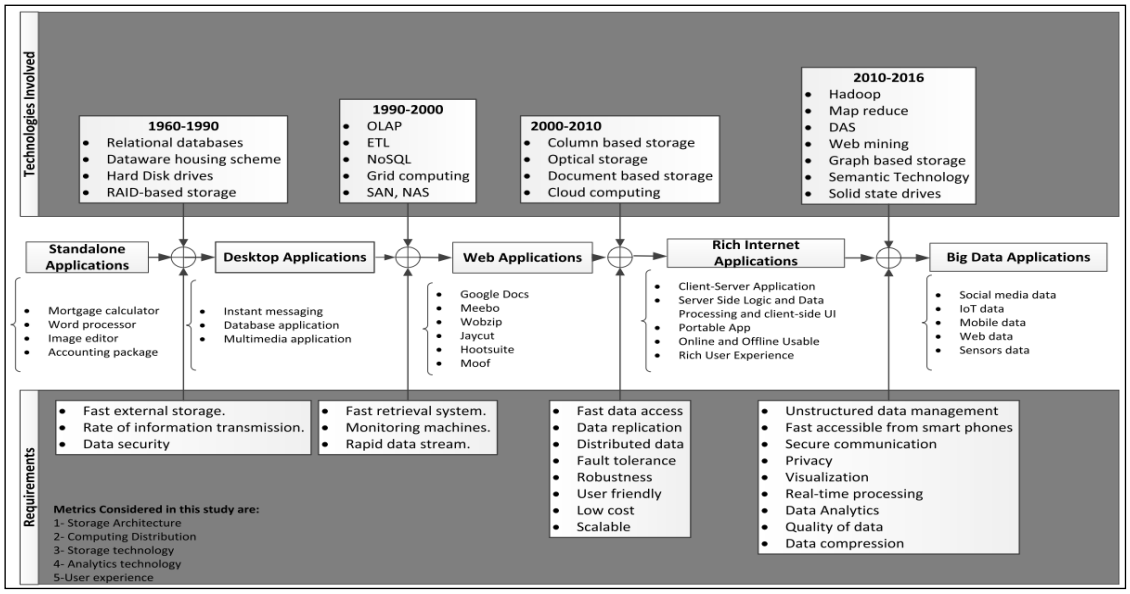

Figure 4. Genesis of Big Data Applications (source: Yaqoob et al., 2016)

Next, Rich Internet Applications with more complex multilevel architecture have become more common as access to internet becomes easier. Finally, current big data applications integrate and combine all these functions and can handle huge amounts of data simultaneously from many sources (Blazquez & Domenech, 2018; Deepa et al., 2022; Jin & Kim, 2018).

Almost every type of technology used nowadays in some way is connected to big data without us even knowing it. Improvement in various sectors from manufacturing, healthcare to tourism has been made through the evolution of big data (Dash et al., 2019; Kuo & Kusiak, 2019; Li et al., 2018). How big data will evolve will be limitless due to its huge potential.

Under the Eleventh Malaysia Plan (RMK11) (2016 to 2020), BDA has been identified as one of the major catalysts of change that will lead the country to the forefront of innovation and sustainability. Thus, major effort has been taken by the Malaysian government to encourage the deployment of BDA. This includes the setting up of Malaysian Digital Economy Corporation Sdn. Bhd. (MDEC), the holistic, government-owned agency that is responsible to pioneer the transformation of Malaysia's digital economy.

According to Malaysia Digital Economy Corp's (MDEC) commissioned study, the BDA market in Malaysia is expected to grow to US$1.9 billion (about RM7. 85 billion) in 2025, from US$1.1 billion in 2021. The study noted that the service sector will contribute 64% of total data–driven spending, with the banking and telecommunications sectors contributing nearly a third. Based on IDC Worldwide Big Data and Analytics Spending Guide 2020, it is noted that Asia Pacific's BDA industry is set for further growth (The Edge Markets, 17 May 2021). MDEC said that BDA is central to Malaysia's digital economy, and this has resulted in the explosive growth of other digital technologies such as artificial intelligence (AI), Internet of Things (IoT), and advanced automation.

3.3.2 BDA Application Tools

Big Data is a collection of information that would have been considered gigantic, impossible to store and process, a decade ago. Now with Big Data Analytics, Big Data management could not have been easier. Data analytics helps businesses to distinguish different characteristics of social, organizational, and technical threats that exist within big data (Al-Dmour et al., 2021). In a day-to-day business sense, BDA acts as a backbone that supports multiple aspects in business operations. Various BDA applications and tools have been developed over the years.

The research and development in BDA have always aimed to further improve and innovate the current system and build an infrastructure, apply data mining, and machine learning algorithms in different areas so that more advanced versions of current methods will become available (Galetsi et al., 2019; Saggi & Jain, 2018). These applications are different, but they operate around similar basis, namely on SQL queries, statistical analysis, data mining, fast clustering, natural language processing, text analytics, data visualization and artificial intelligence (AI) (Vassakis et al., 2018). It is almost impossible to list all kinds of data analytics solutions available in the market. As stated by Williamson (2015), the ecosystem of big data instruments is expanding fast that the current systems will be out of date if we try to list every type of category available. Begum et al., (2019) listed and defined several key big data analyzing tools that can be easily understood. Figure 5 represents the big data analyzing tools.

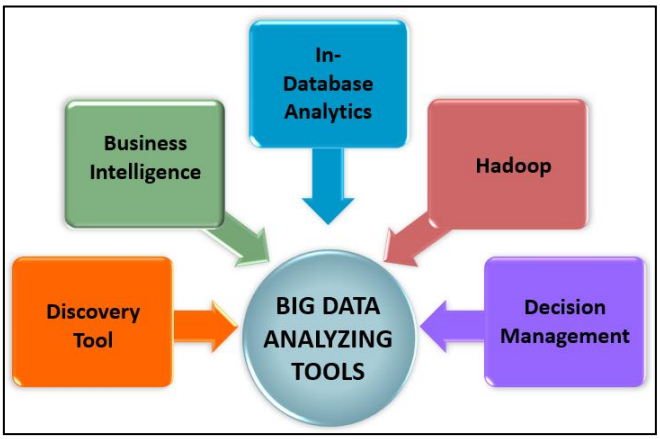

Figure 5. Big Data Analyzing Tools (source: Begum et al., 2019)

I. ***Discovery tools*:** Tool for continuous exploration and analysis of information from combination of structured, unstructured, and semi-structured data source.

II. ***BI (Business Intelligence) tools:*** Tool for analyzing, presenting and performance management, mainly with transactional data warehouse and information systems.

III. ***In-Database Analytics:*** Analytical techniques that permit the processing of data to be applied directly within the database.

IV. ***Hadoop (High-Availability Distributed Object-Oriented Platform):*** Reliable and useful tool for parallelized data processing across computing nodes to enhance computation and reduce latency.

V. ***Decision Management:*** Tool that comprises of predictive modelling, self-learning, and business rules to make well-informed decisions depending on the current situation.

The processing of such large quantities of data imposes methods. A classic database management system is unable to process as much information. Hadoop is an open-source software product (more accurately "software library framework") that is collaboratively produced and freely distributed by the Apache Foundation – effectively, it is a developer's toolkit designed to simplify the building of Big Data solutions. Hadoop is known worldwide as the most popular and successful big data technology system (AtScale, 2020; Fan et al., 2021; Kumar & Singh, 2019). It is like the "flagship" of big data technology. Benlachmi, Yazidi and Hasnaoui (2021) postulated that the basic idea of Hadoop setup is to employ a single server to handle a collection of slave workstation nodes in which each node contains its own local storage and computational resources. For the processing and data storing, Hadoop utilizes the MapReduce algorithm, which divides any given task into smaller parts to distribute them across a set of cluster nodes (Gohil, Garg & Panchal, 2014; Lin & Liu, 2013).

3.3.3 Applications on Big Data Analytics and its Key Data Sources

The potential applications of Big Data in an organization are almost limitless. The application of BDA has been used across multiple industries from healthcare, financial, education, energy and gas, travel, crowdsourcing, and others (Hassan et al., 2021; Kaliraj & Devi, 2022; Pardos, 2017). Chaudhary and Alam (2022) pointed out several applications of BDA in production and inventory management, marketing research, human resource management as well as price setting and optimization among many others. For example, the data collected on consumers' behavior, wants, and needs help keep the flow on inbound logistics and maintain economic order quantity, just-in-time purchases, and ABC analysis of stock items. Table 3 summarizes various applications of BDA, its data sources, and characteristics.

Table 3. Applications on Big Data Analytics and its key data sources (source: Kaliraj & Devi, 2022)

Applications	**Data Sources**	**Characteristics**
Healthcare	Health history of patients, Electronic Health Record (EHR), Medical images, Patients data	Helps enriched monitoring of health, analysis of patient's immune system, a recommendation system for elderly patients.
Network Optimization	Weblog, data of geolocation, sensor data, network user information, Network signal information	Helps proficient network signalling, identification of variation in network, and managing the network.
Travel Estimation	GPS data, Call Data Record (CDR), location data, personal information satellite imagery	Provides data for complicated routes, tracking location, military operation-based recommendation, identification of disease, and emergency.
User Behaviour Modelling	Log data, product review, blog post, social media data, and tweets	Proficient service recommendation.
Human Mobility Modelling	GPS, location data	Helps transportation planning and preserves global movement pattern to facilitate disease

		containment.
Suggestion of services	Reviews provided by the customer, location data, electing the product, buying behaviour data	Enhances product buying experience using customer and potential of products.
Energy Consumption Analysis	Gas status, location data, consumption pattern, and data of meter and usage history	Endorses green energy, attains proficiency through the utilization of energy, prediction, and conservation.
Crowdsourcing and Sensing	Sensor-based sensing data such as accelerometer, magnetometer, gyroscopes, pulse rate, other data sources such as online Questionnaire and survey	Approaches for huge compilation of data
Educational Progression	Information regarding personal, Enrolment, examination, allocation, and contents data	Identifies the student enrolment and rate of failures after the completion of a specific course or session.
Financial Groups	Reports related to financial, blog post, news related to the stock, social media, and regular annual meeting related information	Provides a system for the identification of fraud activity; stirs decision-making for mitigates the circumstances regarding laundering of money.

3.3.4 Big Data Analytics Deployment by Various Industries

The following diagram (Figure 6) depicts various Big Data applications by different industries.

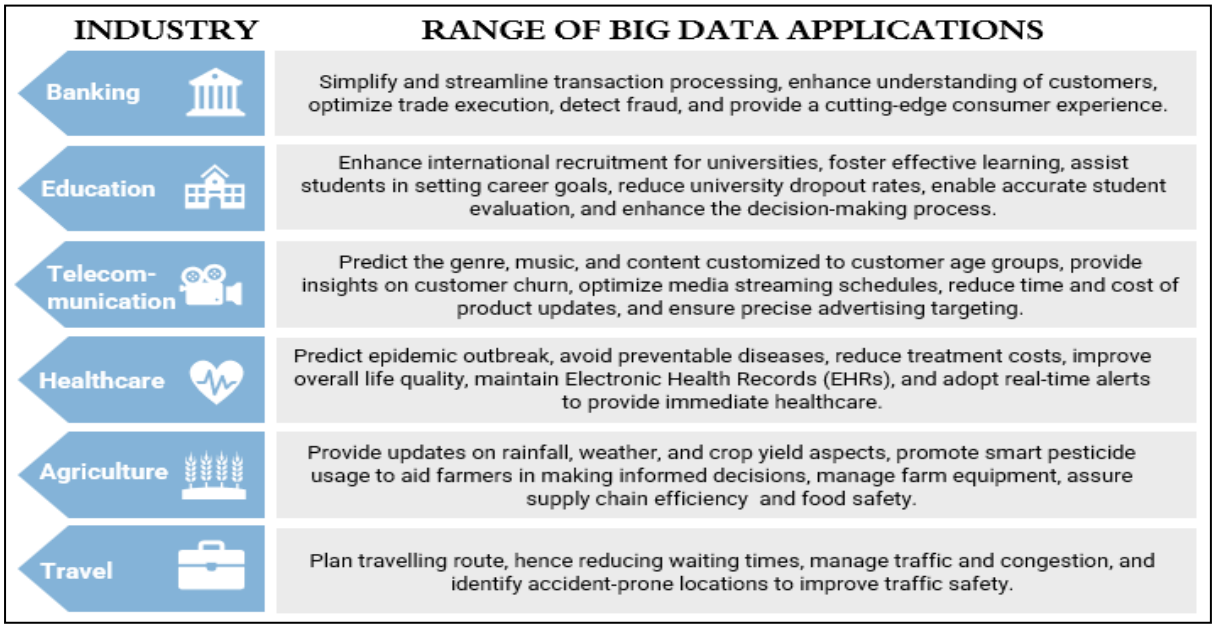

Figure 6. Big Data Applications by Industries (source: authors' original construct, 2023)

(a) Banking Sector

BDA has been widely used for cash collection or financial management to enhance the banking sector. By using the BDA application, it facilitates reducing customer problems, increasing the bank revenue, and making the bank services more transparent and more comprehensible. For example, BDA is employed in identifying fraud, simplifying, and streamlining transaction processing, enhancing understanding of customers, optimizing trade

execution, and facilitating an advanced customer experience. The following examples illustrate some scenarios that BDA application has been used by banking industry.

- An interesting instance of a company utilizing Big Data in this sector is that of Western Union. The organization facilitates an omnichannel approach that customizes consumer experiences by processing over 29 transactions per second and compiling all the data onto a common platform for statistical modelling and predictive analysis.
- JPMorgan Chase and Co (a large bank operating in United States) has employed Big Data technologies of Hadoop in dealing with their massive amount of data. This software allows the bank to generate insights into their customer trends. The application is also able to produce the clients' reports together with generating swift reports for individual examinations.
- From the perspective of the local case, BDA was used by the CIMB Bank to analyze consumer social and digital behavior. As a result, CIMB Bank was able to provide consumers who had limited credit bureau information RM11 million in funding during the second half of 2021. CIMB Bank further updated and refined its machine learning models by adding more data points, so enhancing the accuracy of fraud prediction by 13% to 15%. With the use of a newly developed model, the efficacy of identification of new and old accounts being exploited as mule accounts by criminal organizations increased by 7% (CIMB Sustainability Report, 2021). Big data analytics boosts revenue to grow faster by better aligning CIMB products and services to various customers' needs and segments.

(b) Educational Sector

For the education industry, Big Data has been gathered from either the students, faculties, or courses. The BDA process can generate insights into an effective educational system. It also enhances educational institutional business operations. For instance, through BDA application, the following benefits can be realized, namely BDA application boosts effective learning, enhances international recruiting for universities, facilitates students in setting career goals, reduces university dropouts, allows for precise student evaluation, improves the decision-making process, and enhances student results.

The following examples show how Big Data demonstrates some scenarios where BDA application plays an integral role in this sector.

- In the University of Florida, United States, it has adopted several BDA applications. For instance, IBM InfoSphere was used for extracting, loading, and transferring data via multiple resources, IBM SPSS Modeler in case of predictive analytics and data modelling, and IBM Cognos Analytics for analyzing and predicting student's performance. Additionally, different educational elements ranging from the student's grades, background, demographics, as well as economic background were used to help measure and assess dropout chances for the students. This aids the university in setting its policies and facilitating timely intervention for students on the brink of dropping out.

- In Malaysia, the Malaysian Ministry of Higher Education has inaugurated the first phase of Big Data centers at four Malaysian public universities and one polytechnic based on the consultation by the Prestariang Group (Hanapiyah et al., 2018). It is seen that Big Data Analytics research initiatives at Malaysian institutions remain in their infancy. The importance of BDA in educational sector in Malaysia has also been highlighted in the Report of a Study on Emerging Technology Adoption within Accounting Programmes by Higher Learning Institutions in Malaysia (MIA Technical Report, 2021).

Based on their report, applying data analytics to big data creates vast opportunities for businesses. It can help provide insights based on the data available in the organizations. It can help predict outcomes and automate unstructured tasks. It creates greater value and transforms businesses to be more efficient and productive. Accountants will need skills in data science that can help them to analyze large datasets across the different business functions and determine insights of the business. The MIA Technical Report also emphasizes how data analytics opens new opportunities for accountants to provide vast value-added services to their clients. They can use large datasets from inventory, marketing, customer behavior trends and other data to integrate and analyze these data to arrive at insights to make informed decisions. Data analytics is also used in audits to improve the quality of audits.

Big data deployment benefits the Malaysian higher education institutions in several ways, mainly, it enables; i) impactful research and publications, hence boosting the university's intellectual contribution; ii) personalized adaptive learning and blended learning; iii) digital, experiential learning for improved student experience; iv) re-designed assessment techniques; and v) marketing analytics for improved marketing strategies to attract prospective students (Ashaari et al., 2020).

(c) Telecommunication Industry

The hype for traditional approaches of consuming media is slowly fizzling out as modern approaches of consuming content online via gadgets becomes the new trend. With the enormous amount of data being generated, big data has successfully paved its way into this telecommunication industry. BDA deployment facilitates predicting consumer needs and preferences. For example, there are choices of genre, music, and the media content according to age group, as well as the optimizing media streaming schedule of customers.

- In other cases, the use of Netflix application has become evidence on how big data play the role in the revolutionized media platform. The technology does not only influence the series invested in by the platform, but also how the series is bestowed to their subscribers. The viewing history of the users, even including the points where they have paused the video for any show, impacts everything from the customized thumbnails to the contents we observe on the "Popular on Netflix" section.

- Another instance on the use of the BDA application in telecommunication industry is shown through Viacom18. The company's big data platform is built on Microsoft Azure that is a public cloud computing platform that builds, runs, and manages applications

across multiple clouds. It is one of the biggest cloud platforms on the market, and ideal for mobile application management and deployment as well as gaining insights in business analytics. Microsoft Azure offers a comprehensive set of intelligent solutions for data warehousing, advanced analytics on big data, and real-time streaming.

- Celcom is a leading telco organization in Malaysia, has leveraged IBM's Advanced Analytics Platform and has created an enterprise-wide analytics platform that would serve as the foundation for contextual marketing. Celcom offers highly targeted promotions for their clients' procurement by integrating real-time data of customer consumption. For example, Celcom is capable of identifying prepaid users with low weekend usage and offers them bonus airtime. The advantages of BDA application in Celcom includes driving consumer engagement, developing new services and business models, reducing operational costs, and improving customer satisfaction.

(d) Healthcare Sector

Big Data plays an essential role in enhancing modern healthcare operations. Among the benefits include reducing treatment costs, predicting epidemic outbreaks, avoiding preventable diseases, enhancing overall life quality, predicting the income gained by daily patients to arrange staffing, using Electronic Health Records (EHRs), adopting real-time alerts to facilitate instant care, adopting health data for more effective strategic planning, reducing frauds and errors. Hence, technology has fully revolutionized the healthcare sector.

- A credible example of Big Data in healthcare is Mayo Clinic in the United States. The platform adopts big data analytics to aid in detecting multiple-condition patients and improving their life quality. These analytics can also detect at-risk patients and offer them greater health control and basic medical intervention.

- The Malaysian Health Data Warehouse (MyHDW) was developed by Mimos Bhd. in April 2017 for the Malaysia Health Ministry as a platform to standardize and integrate health data gathered from various sources including public and private hospitals (Sheikh Ahmad et al., 2019); for example, Clinical Administrative Systems, Electronic Health Records and Electronic Medical Records. MyHDW serves as a trusted source of information that can be utilized to improve the healthcare management system, provide surveillance information, and provide a valuable source of research data. Big data analytics allows historical data on the interactions of medicines, equipment, and doctors to provide valuable information for healthcare predictive analytics, as well as to assist in the planning of purchases, training of employees, and improving operational and healthcare efficiency. Notwithstanding, by implementing data science in healthcare, BDA enables valuable data protection of many patients from those criminals who can sell it in the black market.

(e) Agriculture Industry

In the Agriculture field, big data analytics propels smart farming and precision agriculture operations which in turn saves costs and unleashes fresh business opportunities. Some vital areas where big data is put to work include meeting the food demand by supplying farmers

with updates regarding any alterations in rainfall, weather, and factors impacting crop yield, playing a role in propelling smart and accurate use of pesticides to aid farmers in accurate decision making in relation to pesticides, management of farm equipment, ensuring supply chain efficiency, in planning when, where and how to plant seeds and apply chemicals and also in ensuring food safety by gathering data on humidity, temperature, and chemicals for examining a growing plant's health. The following examples illustrate some cases on the BDA deployment in agriculture industry.

- In the United States, Bayer Digital Farming has set up a Bayer Group unit that adopts machine learning and AI for weed identification. Farmers share captures of weeds in the app and then match the picture against a comprehensive Bayer database (having around 100,000 photos) for detecting the species. This app intercedes at the appropriate time, protecting the crops and enhancing yields.
- In another example, a Schneider Electric division has developed BDA application known as Digital Transmission Network (DTN). This application facilitates agricultural information solutions and market intelligence to its customers. Through DTN, farmers and commodity traders can keep track of updated weather and pricing data for handling their business better.
- Thailand is also implementing BDA together with expert systems which are used in various categories to detect, monitor, analyze and predict the crops, thus improve the efficiency and reliability of the precision agriculture (Sreewongcha & Nakasathien, 2020). The so-called SMART platform is a farming management system that monitors the variations of crop, environment, and farmer practices in individual farm upon a combination of satellite or drone images, sensor technologies, mobile applications, positioning technology and the Internet of Things. It improves the process of data acquisition, plantation mapping, soil profiling, database development, planning and decision making.
- From the Malaysian perspective, BDA technology has been developed in modernizing farming and by precision agriculture (PA) techniques via the use of geospatial technology, such as the Oil Palm Resource Information System developed by the Malaysian Palm Oil Board's Biology and Sustainability Research Division for smart precision agriculture. It has been significantly beneficial by its function to map the location of Sustainable Palm Oil Clusters (SPOC) and Malaysian Sustainable Palm Oil (MSPO) Certification areas. It assists researchers in identifying soil types, agro-climatic conditions, and viable planting regions. Most significantly, it aids in the monitoring of pest and disease infestations, which may result in considerable loss of agricultural production and revenue (The Sun Daily, 2021).

(f) Travel Industry

Big Data has played a key role in making the travel industry more flawless and effective. It has affected this sector in managing the revenue gained, earning the reputation, performing effective strategic marketing, holding advanced market research, and conducting targeted

marketing. Likewise, BDA deployment plays a role in planning out the route based on the users' needs by cutting down their waiting time. Moreover, BDA can manage congestion and traffic control through GPS tools like Google maps and Waze application. These applications will detect the least traffic prone routes and identify accident-prone areas to boost the safety level of traffic.

- One of the examples of BDA use in the travelling industry is Uber. The platform generates and adopts a massive degree of data of drivers, locations, vehicles, the trip from each vehicle, to name a few which is then examined and adopted for predicting the demand, supply, location of drivers and established trip fares.
- Another example is Agoda, a Singapore online travel agency for hotels, vacation rentals, flights, and airport transfer. Agoda B2B products include a white-label platform as a B2B "turn-key" solution for partners to provide their customers an online experience that they are used to, from customizable colors, URL, to product selection. In addition to its accommodation booking platform, Agoda also has its own flight product. Agoda uses Vertica technology to accelerate the analysis of billions of data points from all customer journeys as well as powering continuous, ultra-intelligent website optimization.
- Malaysia Airlines operates the GE Digital's Fuel Insight and Flight Pulse aviation software to facilitate fuel efficiency and waste reduction (Travel News Asia, 2021). The fuel efficiency program contributed to a 15% fuel burn improvement recorded over the past eight years. The software uses GE Digital's Event Measurement System (EMS) aviation data and analytics platform to merge flight data with flight plans, load sheets and fuel uplift data, identify the most attainable fuel savings opportunities, and track the incremental savings across the operation. Big data analytics has been a cornerstone of the program with various improvements made in systems infrastructure and capabilities.

4. Challenges of Big Data Analytics (BDA)

The future of Big Data Analytics is constantly evolving over time. It is a dynamic cycle of technological innovation that pushes the limit of current device capabilities. New technologies will always face many challenges during the process of implementation and usage. BDA has been used in many kinds of analytics across multiple industries. Its broad nature poses somewhat different challenges that are unique to their own fields. The success of a Big Data project requires collaboration from multidisciplinary fields and from various sources. To derive at the desired results, all parts in organizational structure need to change simultaneously such as tasks, technologies, people, and structure.

Prior studies have suggested some challenges and barriers to BDA adoption (Hamzah et. Al, 2020; Ganesan et al., 2019; Silvarajah, 2017; Akerker, 2013). Ganesan et al. (2019) stated that interdependent components such as people, process, and technology play an important role in determining the success and failure of Big Data undertaking. Akerker (2013) and Sivarajah (2017) have classified the BDA challenges into three major clusters comprises of

data challenges, process challenges and management challenges. In this paper we conceptualize the challenges of BDA adoption under four main group categories as stated in Figure 7 above; that are: (1) Data-related issues, (2) Security and Privacy-related issues (3) Process-related issues (4) Management-related issues (5) Users-related issues.

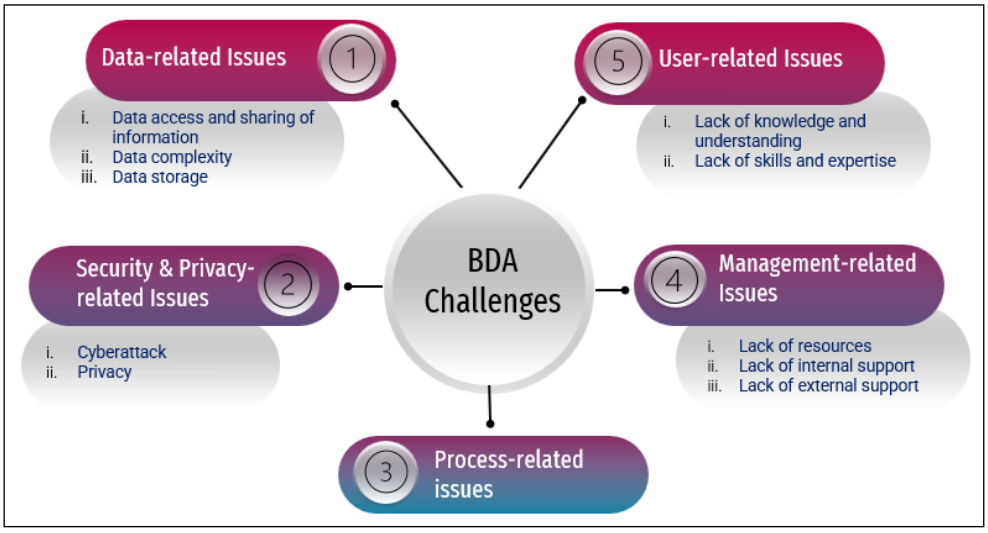

Figure 7. Big Data Analytics (BDA) Challenges (source: authors' original construct, 2023)

4.1 Data-Related Issues

Data-related issues are challenges that relate to the fundamental characteristics of the data itself (data volume, variety, and velocity). The International Data Corporation (IDC) has predicted that the Global Data sphere will grow from 33 Zettabytes in 2018 to 175 Zettabytes by 2025 (Reinsel et al., 2018), hence the uptrend of data related challenges will resume. Semi-structured data and unstructured data will continue to flood the databases as the use of sensors and smart devices increase over the years. It is estimated that around 80% of total data collected consisted of unstructured data that are difficult to deal with (Balusamy et al., 2021; Kaliraj & Devi, 2022). Based on the IDC projections, 80% of worldwide data will be unstructured by 2025 (King 2020). The organizations have explored only a tiny fraction of the digital universe for analytic value. IDC estimates that by 2020, as much as 37 percent of the digital universe will contain information that might be valuable if analyzed (Deloitte, 2017). Amongst data-related issues of BDA include the following (i) data access and sharing of information, (ii) data complexity, and (iii) data storage.

One of the data-related challenges is the data access and sharing of information. To ensure accurate decision making, the data should be accurate, complete, and delivered in a timely manner. Thus, management of big data requires open data that can be accessed by all the stakeholders. For instance, availability of data for government agencies must be provided in a standardized manner with standardized APIs, metadata, and formats, thus leading to better decision making, business intelligence and productivity improvements (Katal, Wazid & Goudar, 2013). They added that from the perspective of the companies, sharing of data for the companies is quite cumbersome because they should be competitive enough to take advantage in business. For example, sharing data about their clients and operations could

jeopardize the culture of secrecy and competitiveness.

Another challenge for data-related issues is data complexity. Data derived from multiple formats (dark data, redundant, and complexity) include a wide range of information streams, log files, master data, and manually entered operator data (Nagorny et al., 2017). The term "dark data" refers to unstructured and inert content, which is fundamentally opposed to critical structured data. However, redundant data is semi-structured information with a high risk of becoming dark (Imdad et al., 2020). The various big data formats lend to the data complexity issue. The complexity of BDA refers to the complex types, complex patterns, and complex structures, making them much harder to observe, interpret, comprehend, and compute with big data (Amalina et al., 2020). Amalina et al. (2020) stated that all these significantly restrict the ability to create effective and efficient strategies for leveraging big data to get insightful information and solve problems (Amalina et al., 2020). BDA complexity of data is also related to the inaccuracy and noise in data.

As this trend upsurges, it will reduce the data quality, lead to bias, and increase threat to internal validity (Galetsi et al., 2019). Nongxa (2017) stated that decision makers suffer timeliness problems from the overload of data. Decision makers now need to be smart in handling different types of BDA insights. This means choosing between high quality answers that are costlier and take longer time to generate or use simpler answers that can be generated quickly to deal with problems before they occur. If no action is taken to adapt with the constant changes in data characteristics, data management will become more challenging and data analytics will take longer time to generate insights that are crucial in decision making.

Thirdly, data storage is another challenge in BDA. Big data needs very large storage devices that operate more quickly and efficiently. To process data and enable to process extraordinarily large amounts of data, there must be accessibility to keep up with expansion and to be able to provide more input/output operations per second (Bhattarai, 2019). Based on Gupta and Rani (2019b), the existing technical advances in data storage, analysis, and management are still not able to keep pace with the exponential growth of big data. Despite the use of cloud technology to supplement the traditional data storage and servers, big data storage is still an issue. This is highlighted by Amalina et al. (2020) that the challenge of storing huge amounts of data into cloud application in real time is still prevalent.

General computational solutions have not been discovered for big data processing particularly when using unstructured data (Kaisler et al., 2015), as it continues to prolong during the pandemic COVID-19 pandemic era (Azeroual & Fabre, 2021). Since a cutting-edge methodology is always required for working at scale with data, this endeavor is always challenged by continuous changes in data structure, and more than ever during the current COVID-19 pandemic, with its incoming unprecedented data processing needs (Azeroual & Fabre, 2021).

4.2 Security and Privacy-Related Issues

The security and privacy related issues have also become another barrier to BDA adoption. The distinctive character of Big Data could easily be susceptible to security and privacy

issues. Priyadarshinee et al., (2017) suggested that security has been evidenced by prior studies as top concerns of business owners when it comes to data-related technologies adoption. Under the security and privacy related category, two interrelated challenges that have become the major concerns are (i) cyberattack and (ii) privacy.

The first challenge within security and privacy-related issues is cyberattack. Cyberattacks are always a constant threat to BDA. Varshney et al., (2020) reported that the numbers of data breaches have increased alarmingly from 44 million cases in the year 2018 to 421 million cases in the year 2019. Other security concerns that can be observed would also include the lack of cloud security architecture and strategy, insecure interfaces, insider threat, account hijacking, and many more (Di Pietro et al., 2021). Information gained to perform BDA is used to improve and empower people. Nevertheless, devious parties will always find ways to exploit BDA insights for their own gain. These parties or corporations operate just at the borderline of ethical and legal limit to make it look legitimate (Marelli et al., 2021).

A security incident is an act that threatens the confidentiality, integrity or availability of information assets and systems. The BDA challenge associated with cyberattack pertaining to three threats are (i) who is attacking and vulnerabilities, (ii) the weaknesses they are attacking and its impacts, and (iii) what the attack does (Fischer, 2014). Based on Zhang et al. (2018), and Sarker et al. (2020), the various types of cybersecurity incidents that may lead to security risks for an organization's systems and networks or an individual include:

(1) Unauthorized access that describes the act of accessing information to network, systems or data without authorization that results in a violation of a security policy.

(2) Malware known as malicious software, is any program or software that is intentionally designed to cause damage to a computer, client, server, or computer network, for instance botnets. Examples of different types of malwares include computer viruses, worms, Trojan horses, adware, ransomware, spyware, malicious bots, and others.

(3) Ransom malware, or ransomware, is an emerging form of malware that prevents users from accessing their systems or personal files, or the devices, then demands an anonymous online payment to restore access.

(4) Denial-of-Service is an attack meant to shut down a machine or network, making it inaccessible to its intended users by flooding the target with traffic that triggers a crash. The Denial-of-Service (DoS) attack typically uses one computer with an Internet connection, while Distributed Denial-of-Service (DDoS) attack uses multiple computers and Internet connections to flood the targeted resource.

(5) Phishing is a type of social engineering that is used for a broad range of malicious activities accomplished through human interactions. A fraudulent attempt takes part to obtain sensitive information such as banking and credit card details, login credentials, or personally identifiable information by disguising oneself as a trusted individual or entity via an electronic communication such as email, text, or instant message and others.

(6) Zero-day attack is considered as the term used to describe the threat of an unknown

security vulnerability for which either the patch has not been released or the application developers were unaware.

Secondly, the privacy issue also falls within the security and privacy-related challenges of BDA. Organizations benefit from many conveniences and breakthroughs due to Big Data-powered applications and services. However, one of the most sensitive issues that organizations feel reluctant to adopt big data is privacy (Ur Rehman et al., 2019; Saleh et al., 2018). It involves the disclosure of personal and sensitive information to people who should not have access to it, whether it is done intentionally or mistakenly. Privacy breaches occur when there are insufficient security measures in place. Safety and diversity can be compromised with the absence of privacy (Saleh et al., 2018).

Since most of the data in the data sets are important, it should be a top priority for organizations to secure the data from security breaches as it may cause serious privacy concerns and the safety of employees and customers could be compromised. Exploitation of data information is a threat to data privacy. Ur Rehman et al., (2019) postulated the action was performed via security breaches or other methods like information leakages, unauthorized data access, and unethical data collection and usage. People are now giving out their precious personal data freely, with the hope that related parties do not abuse it. The rules and regulations that govern data privacy are always lacking and poorly established.

In the developing countries, the application of BDA has raised many concerns particularly in the legal and ethical standpoint since the regulatory framework is not yet robust and widespread (Hassan et al., 2021). Even among large corporations in developing countries like Malaysia, privacy scandals and complacency in handling sensitive information are not that rare (Amalina et al., 2020). Companies and certain parties are treating sensitive information and insights from BDA as a cheap commodity that can be used and traded freely. Some examples would include Facebook's Cambridge Analytica data scandal; Uber's "Hell" tracking software; and Google's Nest Guard hidden microphone "error" (Amalina et al., 2020; Cole et al., 2021; Weiss-Blatt, 2021).

4.3 Process-Related Issues

BDA is a complicated procedure. Different entities generate their own unique sets of data, how data is processed and at what rate it is being processed is different. The amount of capital needed for an organization to provide a conducive environment for effective and efficient data processing is huge. Process-related issues refer to a group of challenges that occurred during the processing and analyzing of the data. Sivarajah et al., (2017) grouped the process-related challenges into five aspects which are data acquisition and warehousing, data mining and cleansing, data integration and aggregation, data analysis and modelling as well as data interpretation. Further explanation by Sivarajah et al., (2017) on the aspects of challenges during the process are: data acquisition and warehousing involves the collection and storage of large amounts of data from a variety of sources, which can be challenging when it comes to dealing with the volume and variety of data, as well as the high velocity at which data is generated.

Data mining and cleansing involves cleaning and preparing the data for analysis, which can be a time-consuming and labor-intensive process that may require specialized skills and expertise. Data integration and aggregation involves integrating and aggregating data from multiple sources to create a comprehensive view of the data, which can be particularly challenging when dealing with data from sources with different formats or structures. Data analysis and modeling involves analyzing and modeling the data to extract valuable insights and inform business decisions and strategy, which can also require specialized skills and expertise. Finally, data interpretation involves accurately interpreting and communicating the results of the data analysis to stakeholders, which can include ensuring that the results are actionable and relevant to the organization's needs.

For example, BDA in manufacturing is vastly work-intensive and requires significant processing and computing power to execute (Azeem et al., 2021). In the old days, manufacturers were only concerned with producing excellent quality products in the most efficient way possible. The business process requires considerations from the external data sources. Companies are now looking at the data collected outside of the factory on the product performance in random environments used by various behavior profiles (Reinsel et al., 2018). Complicated processes also make data and system integration more difficult (Ganesan et al., 2019; Hamzah et al., 2020; Saggi & Jain, 2018). Wang et al., (2018) stated that systems and data integration across multiple sources have proven to be a challenge to BDA. They added that the issue is particularly prevalent when integrating data from legacy systems into BDA frameworks. Overall, these challenges can present significant barriers to the effective use of big data analytics. Therefore, it is important for organizations to be prepared to address these challenges to effectively use and interpret the data.

4.4 Management-Related Issues

Management challenges are dealing with issues that arise when accessing, managing, and governing the data. Several management challenges in BDA include privacy and security issues, data governance and management issues, as well as expenditures issues (Sivarajah et al., 2017). Hamzah et al., (2020) stated that cooperation from multi-disciplinary field and from various sources is difficult to achieve due to organizational resistance. All levels of employees need to ensure data and technology integration among different departments need to be seamless. It is a challenge to keep up with diverse types of expenditures to ensure BDA functions like a well-oiled machine. The management-related issues comprise (i) lack of resources, (ii) lack of internal support, and (iii) lack of external support.

The first challenge within the management-related issue is lack of resources. A lack of resources can present significant challenges for organizations working with big data analytics. In terms of hardware and software, a lack of resources can make it difficult for the organization to effectively process and analyze the data, particularly when it comes to dealing with the volume and variety of data, as well as the high velocity at which data is generated. The lack of resources from the hardware and software infrastructure can present significant challenges for organizations working with big data analytics. To effectively process and analyze substantial amounts of data, organizations need to have the necessary hardware and

software infrastructure in place. This includes sufficient storage capacity to hold the data, as well as the processing power and connectivity needed to analyze the data in a timely manner.

Without the necessary hardware and software infrastructure, organizations may struggle to effectively process and analyze the data. This can be particularly challenging when it comes to dealing with the volume and variety of data, as well as the high velocity at which data is generated. For example, if an organization does not have enough storage capacity, it may be unable to store all the data that it has collected, which can hinder its ability to analyze the data. Similarly, if the organization does not have enough processing power, it may not be able to analyze the data in a timely manner, which can also hinder its ability to extract valuable insights and information from the data.

The implementation of Big Data requires effort from the central agencies with full understanding from agencies in the government to construct in the public sector the data-based activity such as data sharing, digital documentation of the agencies records and establishing open data environment (Al-Sai & Abualigah, 2017). Malaysia is still lacking in adequate ICT resources mainly skilled manpower and state-of-the-art facilities. This includes insufficient investment, unwillingness to share data and lack of success testimonies (Goh, 2015). The high implementation cost for BDA deployment has led to the low levels of BDA adoption among firms. For instance, constant maintenances, data warehousing, workshop, and trainings are considered as expenditures involved in BDA process (Al-Sai et al., 2019; Begum et al., 2019).

To overcome these challenges, organizations may need to invest in additional hardware and software infrastructure, such as a Hadoop cluster or a NoSQL database, to effectively process and analyze the data. This may involve purchasing additional hardware, such as servers and storage devices, as well as investing in software tools and technologies that are designed specifically for big data processing and analysis. By investing in the necessary hardware and software infrastructure, organizations can more effectively process and analyze their data and extract valuable insights and information from them.

The second challenge within the management-related issue is lack of internal support. The success of Big Data projects requires the collaboration from multi-disciplinary fields and from various sources. To get the desired results, all parts in organizational structure need to change simultaneously such as tasks, technologies, people, and structure. Internal support from management is crucial for addressing the challenges that may arise during a big data analytics project. For example, organizational resistance from managers and employees is addressed through adequate internal support. This includes support in terms of resources, such as funding and staffing, as well as support in terms of decision-making and leadership (Vassakis et al., 2018).

Vassakis et al., (2018) further explained that in terms of resources, management must be willing to allocate the necessary funding and staffing to support the project. This is particularly important when it comes to addressing the challenges of dealing with the volume and variety of data, as well as the high velocity at which data are being generated. By providing the necessary resources, management can help ensure that the project has the

necessary hardware and software to store and process the data, as well as the skilled professionals needed to analyze the data. In terms of decision-making and leadership, management must be willing to make decisions based on the data and to provide strong leadership and direction for the project. This includes setting clear goals and objectives for the project and establishing a clear plan for how the data will be used to inform business decisions and strategies. Strong leadership and decision-making are particularly important when it comes to addressing the challenges of ensuring data quality and addressing security and privacy concerns (Vassakis et al., 2018).

Frequently, the organization's lack of understanding of what Big Data is and the technology or infrastructure that will be best suited to them, leads to the failure of utilizing Big Data's benefits. The Big Data concept must be accepted and acknowledged by the top management and then pass on to the manager's level (Hamzah et al., 2020). Therefore, a series of workshops and training is needed to guarantee Big Data comprehension and acceptance. With the acceptance, the management must control and monitor the Big Data implementation and usage throughout the organization's operation. Overall, strong internal support from management is essential for addressing the challenges that may arise during a big data analytics project. Without it, the project is likely to face difficulties and may struggle to achieve its intended results.

Thirdly, the challenges of management-related issues include lack of external support, derived from major stakeholders such as the government as well as private and public organizations. Prior literature has shown that government plays a vital role in the technology adoption (Lutfi et al., 2022, Alsmadi et al., 2022). In Malaysia, there has never been a shortage of policies or blueprints, but the execution has always not met up to expectations, particularly recently. On 19 February 2021, the Malaysia Digital Economy Blueprint/MyDIGITAL Blueprint Initiative (2021–2030) (MyDIGITAL Blueprint Initiative 2021-2030) was introduced. In addition, the current legal framework of BDA in Malaysia is insufficient to effectively regulate user privacy in e-Commerce due to the complexity of big data. Implementing a specific rule pertaining to big data is challenging since lawmakers are struggling to determine the best definition of big data for the Personal Data Protection Act 2010 (PDPA 2010) (Personal Data Protection Act 2010).

Hence, by implementing comprehensive guidelines and providing financial assistance, policy makers can facilitate BDA adoption in businesses. Government can inspire and encourage BDA adoption by providing and promoting technical support, training, independent advice, and other incentives. In addition, the government can offer capital, legislation, and policies to ensure trust and security in modern technologies (Lutfi et al., 2022). Besides, the Malaysian government has initiated awareness campaigns specifically on user-friendliness, up-to-date website content, and accessibility to enhance their support on BDA adoption. Besides, the government should also continue to promote BDA publicly via commentaries on various social networks, internet, magazines, and newspapers to increase stakeholder awareness. On the issue of creating awareness, government agencies, councils, and associations should publish and share materials with organizations through talks, exhibitions, and roadshows to disseminate information that is relevant (Falahat et al., 2022).

External support from management can also refer to the support that an organization receives from external sources, such as vendors, consultants, and partners, to successfully deploy and use big data analytics. External support from management can be particularly useful in addressing the challenges that may arise during a big data analytics project. This support can come in the form of vendors or consultants who can provide expertise and assistance in areas such as data management, statistical analysis, and visualization. These individuals or companies can help organizations overcome the challenges of dealing with the volume and variety of data, as well as the high velocity at which data are generated, by providing the necessary tools and technologies as well as offering training and support.

External support can also be provided through partnerships with other organizations that have experience in big data analytics. These partnerships can help organizations overcome the challenges of ensuring data quality and addressing security and privacy concerns by providing access to additional resources and expertise, as well as the opportunity to collaborate and share knowledge and best practices. Overall, external support from management can be a key factor in addressing the challenges that may arise during a big data analytics project. By accessing the necessary resources and expertise from external sources, organizations can effectively use and interpret the data, and achieve their desired results.

4.5 User-Related Issues

Another challenge in the implementation of data analytics has been rooted from user-related issues comprising (i) lack of knowledge and understanding of technology and (ii) lack of skills and expertise pertaining to the BDA technology. Firstly, lack of knowledge and understanding of the technology involved in working with big data can be a significant challenge for users. This includes a lack of familiarity with the tools and technologies which are used to process and analyze big data, such as Hadoop, Spark, and NoSQL databases.

It may also include a lack of understanding of the statistical and analytical techniques that are used to make sense of the data, such as machine learning algorithms and data visualization techniques. For instance, the practitioners and researchers who are developing big data systems have inadequate information about the current technology and requirements concerning the big data platform. Hence, this leads to difficulty in processing and applying big data as well as choosing the suitable big data tools for development of a big data system (Mohamed et al., 2020). Lack of knowledge leads to difficulty for users to effectively use and understand big data analysis and results. Consequently, it may hinder their ability to make informed decisions based on the data, and lead to incorrect or flawed analyses. This is due to users who may not possess the necessary understanding of the technical aspects of the data, or the tools and techniques being used (Nasser et al., 2015).

Secondly, another user-related issue is on the area of BDA skills and expertise. These attributes are needed for individuals who are proficient in working with big data. This includes a variety of technical skills, such as knowledge of data management, statistical analysis, and visualization techniques. It also includes the ability to use specialized tools and technologies, such as Hadoop, Spark, and NoSQL databases, which are commonly used for big data processing and analysis. The issues arise due to the need for individuals to

understand and interpret the results of big data analyses, and who can use this information to inform business decisions and strategies. In solving the issue of lack of skills, it is crucial to acquire not only technical expertise, but also the ability to communicate complex technical concepts to non-technical stakeholders and to think critically about the implications of the data. Finding individuals with the necessary skills and expertise can be a challenge for organizations, particularly as the demand for big data professionals continues to grow. This may involve training and development of current employees or seeking out individuals with the necessary skills through hiring and recruitment efforts (Nasser et al., 2015).

5. Conclusion

With the current emerging technology trends, BDA will continue to grow in the coming future. Acknowledging the fact, this paper was set out to address the BDA conceptualization and its challenges based upon reviewing the BDA works of literature specifically from the context of the developing country, Malaysia. This study suggests that the BDA concept is manifested from the definition, its applications to the advancement of this innovation. Big Data refers to the massive volumes of unstructured and raw data from various sources. Big Data comes with high veracity and is in high volume, and this requires high computing power to collect and process. Meanwhile, Big Data Analytics (BDA) implies the techniques utilized to examine, process, analyze and expose hidden underlying patterns, interesting relations, and intelligence from huge datasets for different purposes.

In conclusion, big data analytics is a powerful tool that allows organizations to extract valuable insights and information from large and complex data sets. It involves the use of advanced tools and technologies, as well as specialized skills and expertise, to process and analyze data from a variety of sources and types. However, working with big data analytics also presents several challenges, including data-related issues, security and privacy-related issues, process-related issues, management-related issues, and users-related issues. The deployment of big data analytics involves navigating a few issues that can impact the success of the project. These issues include data-related issues, such as the volume and variety of data, the high velocity at which data are generated, and ensuring data quality.

There are also security and privacy-related issues, including the need to protect sensitive information and ensure the security of the data. Process-related issues, such as the selection and implementation of the appropriate tools and technologies, can also impact the success of the project. Management-related issues, such as the need for strong leadership and coordination, are also important considerations. Finally, user-related issues, such as the need for specialized skills and expertise, can impact the ability to effectively use and interpret the results of the data.

To successfully deploy big data analytics, organizations must be prepared to address these issues and invest in the necessary resources to overcome them. To effectively use big data analytics, organizations must be prepared to overcome these challenges through various strategies. In Malaysia, these challenges may be compounded by a lack of skilled professionals and the need to adapt to local regulations and cultural considerations. To successfully deploy big data analytics in Malaysia, organizations must be prepared to invest

in the necessary skills and expertise among their teams, as well as in the tools and technologies needed to process and analyze the data. This may involve training and development programs, as well as hiring individuals with the necessary skills and expertise. By addressing these challenges and investing in the necessary resources, organizations can unlock the valuable insights and information contained within their big data and use it to drive business success.

Acknowledgments

The research described in this paper has been supported by the Research Management Centre (RMC), Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia, under the Geran Penyelidikan Khas (600-RMC/GPK 5/3 020/2020).

References

Acar, O., & Çıtak, Y. E. (2019). Fintech Integration Process Suggestion for Banks. *Procedia Computer Science, 158*, 971-978. https://doi.org/https://doi.org/10.1016/j.procs.2019.09.138

Al-Dmour, H., Saad, N., Basheer Amin, E., Al-Dmour, R., & Al-Dmour, A. (2021). The influence of the practices of big data analytics applications on bank performance: filed study. *VINE Journal of Information and Knowledge Management Systems.* https://doi.org/10.1108/VJIKMS-08-2020-0151

Al-Sai, Z. A., & Abualigah, L. M. (2017, May). *Big data and E-government: A review*. In 2017 8th international conference on information technology (ICIT). IEEE. pp. 580-587.

Al-Sai, Z. A., Abdullah, R., & Husin, M. H. (2019). *Big Data Impacts and Challenges: A Review*. 2019 IEEE Jordan International Joint Conference on Electrical Engineering and Information Technology, JEEIT 2019 - Proceedings, 150-155. https://doi.org/10.1109/JEEIT.2019.8717484

Alam, N., Gupta, L., & Zameni, A. (2019). *Fintech and Islamic Finance: Digitalization, Development and Disruption*. https://doi.org/10.1007/978-3-030-24666-2

Aldridge, I., & Avellaneda, M. (2021). *Big Data Science in Finance* (1st ed.). Wiley.

Alshater, M. M., & Othman, A. H. A. (2020). Financial Technology Developments and their Effect on Islamic Finance Education. *Journal of King Abdulaziz University, Islamic Economics, 33*(3), 187-161. https://doi.org/10.4197/Islec.33-3.9

Amalina, F., Targio Hashem, I. A., Azizul, Z. H., Fong, A. T., Firdaus, A., Imran, M., & Anuar, N. B. (2020). Blending Big Data Analytics: Review on Challenges and a Recent Study. *IEEE Access, 8*, 3629-3645. https://doi.org/10.1109/ACCESS.2019.2923270

Ardagna, C. A., Bellandi, V., Damiani, E., Bezzi, M., & Hebert, C. (2021). Big Data Analytics-as-a-Service: Bridging the gap between security experts and data scientists. *Computers and Electrical Engineering, 93*(July 2020). https://doi.org/10.1016/j.compeleceng.2021.107215

Arena, F., & Pau, G. (2020). An overview of big data analysis. *Bulletin of Electrical*

Engineering and Informatics, 9(4), 1646-1653. https://doi.org/10.11591/eei.v9i4.2359

Arockia Panimalar, S., Varnekha Shree, S. & Veneshia Kathrine, A. (2017). The 17 V's of Big Data, Int. Res. J. Eng. Technol, 4(9), 3-6.

AtScale. (2020). *Big Data & Analytics Maturity 2020 Survey Results*. In At Scale.

Azeem, M., Haleem, A., Bahl, S., Javaid, M., Suman, R., & Nandan, D. (2022). Big data applications to take up major challenges across manufacturing industries: A brief review. *Materials Today: Proceedings, 49*, 339-348. https://doi.org/10.1016/j.matpr.2021.02.147

Azeroual, O., & Fabre, R. (2021). Processing big data with apache hadoop in the current challenging era of COVID-19. *Big Data and Cognitive Computing, 5*(1), 12. https://doi.org/10.3390/bdcc5010012

Balas, V. E., Solanki, V. K., Kumar, R., & Khari, M. (2019). *Internet of Things and Big Data Analytics for Smart Generation* (1st ed.). Springer International Publishing. https://doi.org/10.1007/978-3-030-04203-5

Balusamy, B., R, N. A., Kadry, S., & Gandomi, A. H. (2021). *Big Data Concepts Technology and Architecture*. Wiley. https://doi.org/10.1002/9781119701859

Barbosa, M. W., Vicente, A. de la C., Ladeira, M. B., & Oliveira, M. P. V. de. (2018). Managing supply chain resources with Big Data Analytics: a systematic review. *International Journal of Logistics Research and Applications, 21*(3), 177-200. https://doi.org/10.1080/13675567.2017.1369501

Beer, D. (2016). How should we do the history of Big Data? *Big Data and Society, 3*(1), 1-10. https://doi.org/10.1177/2053951716646135

Begum, A., Fatima, F., & Haneef, R. (2019). Big Data and Advanced Analytics. *Advances in Intelligent Systems and Computing, 918*, 594-601. https://doi.org/10.1007/978-3-030-11890-7_57

Benlachmi, Y., El Yazidi, A., & Hasnaoui, M. L. (2021). A Comparative Analysis of Hadoop and Spark Frameworks using Word Count Algorithm. *International Journal of Advanced Computer Science and Applications, 12*(4). https://doi.org/10.14569/IJACSA.2021.0120495

Bhat, W. A. (2018). Bridging data-capacity gap in big data storage. *Future Generation Computer Systems, 87*, 538-548. https://doi.org/https://doi.org/10.1016/j.future.2017.12.066

Blakstad, S., & Allen, R. (2018). *FinTech Revolution* (1st ed.). Palgrave Macmillan. https://doi.org/10.1007/978-3-319-76014-8

Blazquez, D., & Domenech, J. (2018). Big Data sources and methods for social and economic analyses. *Technological Forecasting and Social Change, 130*(September 2017), 99-113. https://doi.org/10.1016/j.techfore.2017.07.027

Broeders, D., & Prenio, J. (2018). FSI Insights: Innovative technology in financial supervision. *FSI Insights on Policy Implementation, July*(9), 29.

Bujang, A. S., & Abu Bakar, B. H. (2019). *Precision Agriculture in Malaysia*. FFTC Agricultural Policy Platform, Food and Fertilizer Technology Center for the Asian and Pacific Region.

Chaudhary, K., & Alam, M. (2022). *Big Data Analytics: Applications in Business and Marketing* (1st ed.). Auerbach Publications. https://doi.org/10.1201/9781003307761

Chen, H., Chiang, R. H. L., & Storey, V. C. (2012). Business Intelligence and Analytics: From Big Data to Big Impact. *MIS Q., 36*(4), 1165-1188. https://doi.org/10.2307/41703503

Chiu, I. (2017). A New Era in Fintech Payment Innovations? A Perspective from the Institutions and Regulation of Payment Systems. *Law, Innovation and Technology, 9*. https://doi.org/10.1080/17579961.2017.1377912

Cobb, A. N., Benjamin, A. J., Huang, E. S., & Kuo, P. C. (2018). Big data: More than big data sets. *Surgery, 164*(4), 640-642. https://doi.org/https://doi.org/10.1016/j.surg.2018.06.022

Cole, R., Johan, S., & Schweizer, D. (2021). Corporate failures: Declines, collapses, and scandals. *Journal of Corporate Finance, 67*(December 2020), 101872. https://doi.org/10.1016/j.jcorpfin.2020.101872

Crosman, P. (2018). How artificial intelligence is reshaping jobs in banking. *American Banker, 183*(88), 1-3. [Online] Available: https://web.a.ebscohost.com/ehost/detail/detail?vid=0&sid=3ad3135e-dbaf-4ff5-abf0-8d7849afb0d3%40sdc-v-sessmgr06&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3D%3D#db=bth&AN=129468404

Dash, S., Shakyawar, S. K., Sharma, M., & Kaushik, S. (2019). Big data in healthcare: management, analysis, and prospects. *Journal of Big Data, 6*(1). https://doi.org/10.1186/s40537-019-0217-0

Deepa, N., Pham, Q.-V., Nguyen, D. C., Bhattacharya, S., Prabadevi, B., … Pathirana, P. N. (2022). A survey on blockchain for big data: Approaches, opportunities, and future directions. *Future Generation Computer Systems, 131*, 209-226. https://doi.org/10.1016/j.future.2022.01.017

Di Pietro, R., Raponi, S., Caprolu, M., & Cresci, S. (2021). *New Dimensions of Information Warfare*. In Advances in Information Security, Vol. 84. Springer. https://doi.org/10.1007/978-3-030-60618-3

Errol S. van Engelen. (2019). *New world technologies: 2020 and beyond* (1st ed.).

Falahat, M., Cheah, P. K., Jayabalan, J., Lee, C. M. J., & Kai, S. B. (2022). Big Data Analytics Capability Ecosystem Model for SMEs. *Sustainability, 15*(1), 360. https://doi.org/10.3390/su15010360

Fan, Z., Zhou, H., Chen, Z., Hong, D., Wang, Y., & Dong, Q. (2021). Design and implementation of scientific research big data service platform for experimental data management. *Procedia Computer Science, 192*, 3875-3884.

https://doi.org/10.1016/j.procs.2021.09.162

Faraway, J. J., & Augustin, N. H. (2018). When small data beats big data. *Statistics & Probability Letters, 136*, 142-145. https://doi.org/10.1016/j.spl.2018.02.031

Ferreira, D., & Vale, M. (2020). Geography in the Big Data Age: An Overview of the Historical Resonance of Current Debates. *Geographical Review, 112*(2), 250-266. https://doi.org/10.1080/00167428.2020.1832424

Fischer, E. A. (2014). *Cybersecurity issues and challenges: In brief.* Congressional Research Service.

Fischer, E. A. (2014). *Federal laws relating to cybersecurity: Overview of major issues, current laws, and proposed legislation.*

Fosso Wamba, S., Akter, S., Edwards, A., Chopin, G., & Gnanzou, D. (2015). How 'big data' can make big impact: Findings from a systematic review and a longitudinal case study. *International Journal of Production Economics, 165*, 234-246. https://doi.org/10.1016/j.ijpe.2014.12.031

Fowdur, T., Beeharry, Y., Hurbungs, V., Bassoo, V., & Ramnarain-Seetohul, V. (2018). *Big Data Analytics with Machine Learning Tools*. In Internet of Things and Big Data Analytics Toward Next-Generation Intelligence (pp. 49-97). https://doi.org/10.1007/978-3-319-60435-0_3

Galetsi, P., Katsaliaki, K., & Kumar, S. (2019). Values, challenges, and future directions of big data analytics in healthcare: A systematic review. *Social Science and Medicine, 241*(September), 112533. https://doi.org/10.1016/j.socscimed.2019.112533

Gandomi, A., & Haider, M. (2015). Beyond the hype: Big data concepts, methods, and analytics. *International Journal of Information Management, 35*(2), 137-144. https://doi.org/10.1016/j.ijinfomgt.2014.10.007

Ganesan, S., Arul Kumar, M., & Gopalsamy, S. (2019). Trends of big data analytics: Impacts and difficulties review. *International Journal of Advanced Science and Technology, 28*(19), 1260-1266.

Gantz, J., & Reinsel, D. (2011). Extracting Value from Chaos. *IDC Iview, 1142*(2011), 1-12.

Ghani, N. A., Hamid, S., Targio Hashem, I. A., & Ahmed, E. (2019). Social media big data analytics: A survey. *Computers in Human Behavior, 101*, 417-428. https://doi.org/10.1016/j.chb.2018.08.039

Gohil, P. Garg, D., & Panchal, B. (2014). *A performance analysis of MapReduce applications on big data in cloud-based Hadoop in 2014 International Conference on Information Communication and Embedded Systems*. ICICES 2014, IEEE: pp. 1-6, 2015. https://doi.org/10.1109/ICICES.2014.7033791

Gökalp, M. O., Gökalp, E., Kayabay, K., Gökalp, S., Koçyiğit, A., & Eren, P. E. (2022). A process assessment model for big data analytics. *Computer Standards & Interfaces, 80*,

103585. https://doi.org/10.1016/j.csi.2021.103585

Goldstein, I., Spatt, C. S., & Ye, M. (2021). Big data in finance. *The Review of Financial Studies, 34*(7), 3213-3225. https://doi.org/10.1093/rfs/hhab038

Gupta, D., & Rani, R. (2019a). A study of big data evolution and research challenges. *Journal of Information Science, 45*(3), 322-340. https://doi.org/10.1177/0165551518789880

Gupta, D., & Rani, R. (2019b). A study of big data evolution and research challenges. *Journal of Information Science, 45*(3), 322-340. https://doi.org/10.1177/0165551518789880

Gutmann, M. P., Merchant, E. K., & Roberts, E. (2018). "Big Data" in Economic History. *The Journal of Economic History, 78*(1), 268-299. https://doi.org/10.1017/S0022050718000177

Hajjaji, Y., Boulila, W., Farah, I. R., Romdhani, I., & Hussain, A. (2021). Big data and IoT-based applications in smart environments: A systematic review. *Computer Science Review, 39*, 100318. https://doi.org/10.1016/j.cosrev.2020.100318

Hamzah, M. A., Mat Yatin, S. F., Yusof, M., Rashid, T. S. L. T. Z., Shuhaimi, H., Suleiman, A. B., Mansor, A. N., & Taib, K. M. (2020). Big Data Implementation in Malaysian Public Sector: A Review. *International Journal of Academic Research in Business and Social Sciences, 10*(11), 1461-1474. https://doi.org/10.6007/ijarbss/v10-i11/9072

Hassan, S., Dhali, M., Zaman, F., & Tanveer, M. (2021). Big data and predictive analytics in healthcare in Bangladesh: regulatory challenges. *Heliyon, 7*(6). https://doi.org/10.1016/j.heliyon.2021.e07179

Hernández, E., Öztürk, M., Sittón, I., & Rodríguez, S. (2019). Data Protection on Fintech Platforms BT - Highlights of Practical Applications of Survivable Agents and Multi-Agent Systems. In F. De La Prieta, A. González-Briones, P. Pawleski, D. Calvaresi, E. Del Val, F. Lopes, V. Julian, E. Osaba, & R. Sánchez-Iborra (Eds.), *The PAAMS Collection* (pp. 223-233). Springer International Publishing.

Hornuf, L., Klus, M., Lohwasser, T., & Schwienbacher, A. (2021). How do banks interact with fintech startups? *Small Business Economics, 57*. https://doi.org/10.2139/ssrn.3252318

Iman, N. (2019). Traditional banks against fintech startups: a field investigation of a regional bank in Indonesia. *Banks and Bank Systems, 14*, 20-33. https://doi.org/10.21511/bbs.14(3).2019.03

Imdad, M., Din, M. J. U., & Mohsin, S. (2020). Dark Data: Opportunities and challenges. *International Research Journal in Computer Science and Technology, 1*(1), 38-46.

Inoubli, W., Aridhi, S., Mezni, H., Maddouri, M., & Mephu Nguifo, E. (2018). An experimental survey on big data frameworks. *Future Generation Computer Systems, 86*, 546-564. https://doi.org/https://doi.org/10.1016/j.future.2018.04.032

Ishikiriyama, C. S., & Gomes, C. F. S. (2019). Big Data: A Global Overview. In A. Emrouznejad & V. Charles, (Eds.), *Big Data for the Greater Good. Studies in Big Data*, vol

42. Springer, Cham. https://doi.org/10.1007/978-3-319-93061-9_3

Jagtiani, J., & John, K. (2018). Fintech: The Impact on Consumers and Regulatory Responses. *Journal of Economics and Business, 100*, 1-6. https://doi.org/10.1016/j.jeconbus.2018.11.002

Jaiswal, M. (2018). Big Data Concept and Imposts in Business. *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.3772405

Jamil, N. N., & Abu Seman, J. (2019). The Impact of Fintech on The Sustainability of Islamic Accounting and Finance Education in Malaysia. *Journal of Islamic, Social, Economics and Development (JISED), 4*(17), 74-88.

Jin, D. H., & Kim, H. J. (2018). Integrated understanding of big data, big data analysis, and business intelligence: A case study of logistics. *Sustainability (Switzerland), 10*(10). https://doi.org/10.3390/su10103778

Kaliraj, P., & Devi, T. (2022). *Big Data Applications in Industry 4.0.* In Big Data Applications in Industry 4.0 (1st ed.). CRC Press. https://doi.org/10.1201/9781003175889

Kang, J. (2018). Mobile payment in Fintech environment: trends, security challenges, and services. *Human-Centric Computing and Information Sciences, 8*(1), 32. https://doi.org/10.1186/s13673-018-0155-4

Kavuri, A., & Milne, A. K. L. (2018). Fintech and the Future of Financial Services: What are the Research Gaps? *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.3215849

Kostakis, P., & Kargas, A. (2021). Big-data management: A driver for digital transformation? *Information (Switzerland), 12*(10). https://doi.org/10.3390/info12100411

Kumar, S., & Singh, M. (2019). Big data analytics for healthcare industry: Impact, applications, and tools. *Big Data Mining and Analytics, 2*(1), 48-57. https://doi.org/10.26599/BDMA.2018.9020031

Kuo, Y. H., & Kusiak, A. (2019). From data to big data in production research: the past and future trends. *International Journal of Production Research, 57*(15-16), 4828-4853. https://doi.org/10.1080/00207543.2018.1443230

Kwon, O., Lee, N., & Shin, B. (2014). Data quality management, data usage experience and acquisition intention of big data analytics. *International Journal of Information Management, 34*(3), 387-394. https://doi.org/https://doi.org/10.1016/j.ijinfomgt.2014.02.002

Labrinidis, A., & Jagadish, H. V. (2012). Challenges and opportunities with big data. *Proceedings of the VLDB Endowment, 5*, 2032-2033. https://doi.org/10.14778/2367502.2367572

Laney, D. (2001). *3D Data Management: Controlling Data Volume*. In Application Delivery Strategies (Issue February 2001, p. 4). [Online] Available: http://blogs.gartner.com/doug-laney/files/2012/01/ad949-3D-Data-Management-Controlling-Data-Volume-Velocity-and-Variety.pdf

Lee, I., & Shin, Y. J. (2018). Fintech: Ecosystem, business models, investment decisions, and challenges. *Business Horizons, 61*(1), 35-46. https://doi.org/10.1016/j.bushor.2017.09.003

Li, J., Xu, L., Tang, L., Wang, S., & Li, L. (2018). Big data in tourism research: A literature review. *Tourism Management, 68*, 301-323. https://doi.org/10.1016/j.tourman.2018.03.009

Liao, Z., Yin, Q., Huang, Y., & Sheng, L. (2014). Management and application of mobile big data. *International Journal of Embedded Systems, 7*(1), 63-70. https://doi.org/10.1504/IJES.2015.066143

Lin, C., Kunnathur, A. S., & Li, L. (2020). Conceptualizing big data practices. International *Journal of Accounting and Information Management, 28*(2), 205-222. https://doi.org/10.1108/IJAIM-12-2018-0154

Lutfi, A., Alrawad, M., Alsyouf, A., Almaiah, M. A., Al-Khasawneh, A., Al-Khasawneh, A. L., ... & Ibrahim, N. (2023). Drivers and impact of big data analytic adoption in the retail industry: A quantitative investigation applying structural equation modeling. *Journal of Retailing and Consumer Services, 70*, 103129. https://doi.org/10.1016/j.jretconser.2022.103129

Lutfi, A., Alshira'h, A. F., Alshirah, M. H., Al-Okaily, M., Alqudah, H., Saad, M., ... Abdelmaksoud, O. (2022). Antecedents and Impacts of Enterprise Resource Planning System Adoption among Jordanian SMEs. *Sustainability, 14*(6), 3508. https://doi.org/10.3390/su14063508

Mariani, M. C. (2021). *Data Science in Theory and Practice: Techniques for Big Data Analytics and Complex Data Sets* (1st ed.). Wiley. https://doi.org/10.1002/9781119674757

Marr, B. (2022). *Data strategy: how to profit from a world of big data, analytics, and artificial intelligence* (2nd ed.). Kogan Page.

Mehrban, S., Nadeem, M. W., Hussain, M., Ahmed, M. M., Hakeem, O., Saqib, S., Kiah, M. L. M., Abbas, F., Hassan, M., & Khan, M. A. (2020). Towards Secure FinTech: A Survey, Taxonomy, and Open Research Challenges. *IEEE Access, 8*, 23391-23406. https://doi.org/10.1109/ACCESS.2020.2970430

Mei, S., Peiguang, L., & Xiushan, N. (2018). *Research on fintech industry development and talent training status.* 13th International Conference on Computer Science and Education, ICCSE 2018, Iccse, 384-387. https://doi.org/10.1109/ICCSE.2018.8468796

Mészáros, J., & Ho, C. H. (2018). Big data and scientific research: The secondary use of personal data under the research exemption in the GDPR. *Hungarian Journal of Legal Studies, 59*(4), 403-419. https://doi.org/10.1556/2052.2018.59.4.5

Mishra, B. K., Kumar, V., Panda, S. K., & Tiwari, P. (2021). *Handbook of Research for Big Data: Concepts and Techniques* (1st ed.). Apple Academic Press.

Miskam, S., Shahwahid, F., & Sholehuddin, N. (2018). *Catching the Fintech Wave in Islamic Finance: Regulatory Approach for Malaysia.* 4th Muzakarah Fiqh & International Fiqh

Conference (MFIFC 2018), 223-235. https://doi.org/10.1108/978-1-78973-545-120191019

Mohamed, A., Najafabadi, M. K., Wah, Y. B., Zaman, E. A. K., & Maskat, R. (2020). The state of the art and taxonomy of big data analytics: view from new big data framework. *Artificial Intelligence Review, 53*(2), 989-1037. https://doi.org/10.1007/s10462-019-09685-9

Monserrate, S. G. (2022). *The Cloud Is Material: On the Environmental Impacts of Computation and Data Storage*. MIT Case Studies in Social and Ethical Responsibilities of Computing, Winter 2022, 1-35. https://doi.org/10.21428/2c646de5.031d4553

Mosteanu, N. R. (2020). Challenges for organizational structure and design as a result of digitalization and cybersecurity. *The Business and Management Review, 11*. https://doi.org/10.24052/BMR/V11NU01/ART-29

MyDIGITAL Blueprint Initiative 2021-2030. (2021). *Economic Planning Unit, Prime Minister's Department: Putrajaya, Malaysia*.

Naeem, M., Jamal, T., Diaz-Martinez, J., Butt, S. A., Montesano, N., Tariq, M. I., ... De-La-Hoz-Valdiris, E. (2022). *Trends and future perspective challenges in big data.* In Advances in intelligent data analysis and applications (pp. 309-325). Springer, Singapore. https://doi.org/10.1007/978-981-16-5036-9_30

Nagorny, K., Lima-Monteiro, P., Barata, J., & Armando, W. (2017). Colombo Big Data Analysis in Smart Manufacturing: A Review. *International Journal of Communications, Network and System Sciences, 10*(3), 31-58. https://doi.org/10.4236/ijcns.2017.103003

Ng, A., & Kwok, B. (2017). Emergence of Fintech and cybersecurity in a global financial center: Strategic approach by a regulator. *Journal of Financial Regulation and Compliance, 25*, 0. https://doi.org/10.1108/JFRC-01-2017-0013

Nongxa, L. G. (2017). Mathematical and statistical foundations and challenges of (big) data sciences. *South African Journal of Science, 113*(3-4), 1-4. https://doi.org/10.17159/sajs.2017/a0200

O'Hanlon, S., Chishti, S., Bradley, B., Jockle, J., & Patrick, D. (2020). *FinTech For Dummies.* John Wiley & Sons.

Oeshwik, A., & Benazir, R. (2020). Employees of commercial banks learning to unlearn: a case study on the impact of electronic banking in the commercial banks of Bangladesh. *International Journal of Business and Technopreneurship, 10*(1), 31-50.

Pardos, Z. A. (2017). Big data in education and the models that love them. *Current Opinion in Behavioral Sciences, 18*, 107-113. https://doi.org/10.1016/j.cobeha.2017.11.006

Personal Data Protection Act 2010; Act 709. (2010). *Percetakan Nasional Malaysia Berhad: Kuala Lumpur, Malaysia.*

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

Piccarozzi, M., & Aquilani, B. (2022). The role of Big Data in the business challenge of Covid-19: a systematic literature review in managerial studies. *Procedia Computer Science, 200*, 1746-1755. https://doi.org/10.1016/j.procs.2022.01.375

Priyadarshinee, P., Raut, R. D., Jha, M. K., & Kamble, S. S. (2017). A cloud computing adoption in Indian SMEs: Scale development and validation approach. *The Journal of High Technology Management Research, 28*(2), 221-245. https://doi.org/10.1016/j.hitech.2017.10.010

PwC. (2016). *Security challenges in the evolving fintech landscape.* PwC. [Online] Available: https://www.pwc.in/assets/pdfs/consulting/cyber-security/banking/security-challenges-in-the-evolving-fintech-landscape.pdf

Raut, R. D., Mangla, S. K., Narwane, V. S., Gardas, B. B., Priyadarshinee, P., & Narkhede, B. E. (2019). Linking big data analytics and operational sustainability practices for sustainable business management. *Journal of Cleaner Production, 224*, 10-24. https://doi.org/10.1016/j.jclepro.2019.03.181

Reinsel, D., Gantz, J., & Rydning, J. (2018). *The Digitization of the World - From Edge to Core.* Framingham: International Data Corporation, November, US44413318. [Online] Available: https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage-whitepaper.pdf

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

Saggi, M. K., & Jain, S. (2018). A survey towards an integration of big data analytics to big insights for value-creation. *Information Processing and Management, 54*(5), 758-790. https://doi.org/10.1016/j.ipm.2018.01.010

Saleh, S. H., Ismail, R., Ibrahim, Z., & Hussin, N. (2018). Issues, Challenges and Solutions of Big Data in Information Management: An Overview. *International Journal of Academic Research in Business and Social Sciences, 8*(12), 1382-1393. https://doi.org/10.6007/IJARBSS/v8-i12/5240

Shah, T., Rabhi, F., & Ray, P. (2014). Investigating an ontology-based approach for Big Data analysis of inter-dependent medical and oral health conditions. *Cluster Computing, 18*, 351-367. https://doi.org/10.1007/s10586-014-0406-8

Sheikh Ahmad, M. K., Mohd Sulaiman, I. Mohd Sakri, M. S., Ismail, O., Mazlan, M. A., & Latip, A. A. (2019). *Integrating MyHarmony (Harmonization & Codification of Unstructured Data using SNOMED CT) with Malaysian Health Data Warehouse.* SNOMED CT EXPO 2019, Kuala Lumpur, Malaysia

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. https://doi.org/10.1016/j.jbusres.2016.08.001

Sloboda, L., & Demianyk, O. (2020). Prospects and Risks of the Fintech Initiatives in a

Global Banking Industry. *The Problems of Economy, 1*, 275-282. https://doi.org/10.32983/2222-0712-2020-1-275-282

Sreewongcha, T., & Nakasathien, S. (2020). *Smart Platform for Precision Agriculture in Thailand.* FFTC Agricultural Policy Platform, Food and Fertilizer Technology Center for the Asian and Pacific Region.

Stewart, H., & Jürjens, J. (2018). Data security and consumer trust in FinTech innovation in Germany. *Information & Computer Security, 26*(1), 109-128. https://doi.org/10.1108/ICS-06-2017-0039

Sun, N., Zhang, J., Rimba, P., Gao, S., Zhang, L. Y., & Xiang, Y. (2018). Data-Driven Cybersecurity Incident Prediction: A Survey. *IEEE Communications Surveys & Tutorials, 21*(2), 1744-1772. https://doi.org/10.1109/COMST.2018.2885561

Talaoui, Y., Kohtamäki, M., Ranta, M., & Paroutis, S. (2023). *Recovering the divide: A review of the big data analytics-strategy relationship*. Long Range Planning, 102290. https://doi.org/10.1016/j.lrp.2022.102290

Travel News Asia. (2021). *Malaysia Airlines to Implement GE Digital's Fuel Insight and FlightPulse Software*. [Online] Available: https://www.travelnewsasia.com/news21/58-MalaysiaAirlines.shtml

University of Malaya Malaysian Centre of Regulatory Studies. (2018). *Malaysian Blockchain Regulatory Report.*

Ur Rehman, M. H., Yaqoob, I., Salah, K., Imran, M., Jayaraman, P. P., & Perera, C. (2019). The role of big data analytics in industrial Internet of Things. *Future Generation Computer Systems, 99*, 247-259. https://doi.org/10.1016/j.future.2019.04.020

Varshney, S, Munjal, D., Bhattacharya, O., Saboo, S., & Aggarwal, N. (2020). *Big Data Privacy Breach Prevention Strategies*. 2020 IEEE International Symposium on Sustainable Energy, Signal Processing and Cyber Security (ISSSC), 1-6. https://doi.org/10.1109/iSSSC50941.2020.9358878

Varshney, Shipra, Munjal, D., Bhattacharya, O., Saboo, S., & Aggarwal, N. (2020). *Big data privacy breach prevention strategies*. Proceedings - 2020 IEEE International Symposium on Sustainable Energy, Signal Processing and Cyber Security, ISSSC 2020. https://doi.org/10.1109/iSSSC50941.2020.9358878

Vassakis, K., Petrakis, E., & Kopanakis, I. (2018). Big data analytics: Applications, prospects, and challenges. *Lecture Notes on Data Engineering and Communications Technologies, 10*, 3-20. https://doi.org/10.1007/978-3-319-67925-9_1

Wahab, S. N., Hamzah, M. I., Sayuti, N. M., Lee, W. C., & Tan, S. Y. (2021). Big data analytics adoption: an empirical study in the Malaysian warehousing sector. *International Journal of Logistics Systems and Management, 40*(1), 121-144. https://doi.org/10.1504/IJLSM.2021.117703

Wang, Y., Kung, L. A., & Byrd, T. A. (2018). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. *Technological Forecasting and Social Change, 126*, 3-13. https://doi.org/10.1016/j.techfore.2015.12.019

Weiss-Blatt, N. (2021). *Big Tech - Big Scandals*. In The Techlash and Tech Crisis Communication (pp. 37-72). Emerald Publishing Limited. https://doi.org/10.1108/978-1-80043-085-320211007

Williamson, J. (2015). *Getting a Big Data Job for Dummies* (1st ed.). John Wiley & Sons.

Yaqoob, I., Hashem, I. A. T., Gani, A., Mokhtar, S., Ahmed, E., Anuar, N. B., & Vasilakos, A. V. (2016). Big data: From beginning to future. *International Journal of Information Management, 36*(6), 1231-1247. https://doi.org/10.1016/j.ijinfomgt.2016.07.009

Vassakis, K., Petrakis, E., & Kopanakis, I. (2018). *Big data analytics: applications, prospects.* https://doi.org/10.1007/978-3-319-67925-9_1

Nasser, T., & Tariq, R. S. (2015). Big data challenges. *J Computer Eng Inf Technol, 4*, 3. https://doi.org/10.4172/2324-9307.1000133

Copyright Disclaimer