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REVIEW



Role of Big Data Analytics in supply chain management: current trends and future perspectives

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ABSTRACT

It is a widely accepted fact that almost every research or business revolves around Data. Data from various business sectors has been growing sharply and the management of this massive amount of data is the biggest professional crunch these days. The notion of Big Data Analytics (BDA) is a prominent facet that delivers the best possible solution to decision-makers for efficiently handling the problems related to huge data. The key role of BDA in the area of Supply Chain Management (SCM), Logistics Management (LM), and Inventory Management (IM) is of utmost significance as it optimises the business operations by analyzing customer behaviour. Motivated with the promising paybacks of the BDA, a recent review from the year 2015–2019 is presented in this paper. Further, the significance of BDA in SCM, LM, and IM has been highlighted by studying 58 papers, which have been sorted after a detailed study of 260 papers, collected through the Web of Science (WoS) database. The findings and observations give state-of-the-art insights to scientists and business professionals by presenting an exhaustive list of the progress made and challenges left untackled in the field of BDA in SCM, LM, and IM.

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Big Data Analytics; supply chain management; logistics; inventory management; review

1. Introduction

In today's data-driven world, the supply chain (SC) systems have turned gradually complex. As the data accrued by the SC possesses details from major key components, viz. production planning systems, logistics, quality and IM systems, e-commerce, and retail. The data has been collected at a rapid pace from different resources and services (Benabdellah, Benghabrit, and Bouhaddou 2019). Currently, SC have been tremendously buoyed by modern networking skills, tags, sensors, tracks, and various smart devices, which have been collecting data on a real-time scale (Giannakis, Spanaki, and Dubey 2019). This enables end-to-end supply and demand visibility. With the growing adoption of Data analytics (DA) by companies, scholars have emphasized the necessity to foster an improved understanding of how BDA applications can be a potent resource for SC companies to acquire competitive benefits (Hofmann 2017; Verma and Bhattacharyya 2017; Mishra et al. 2018). Thus, SC managers have been switching towards BDA for handling complex and huge datasets.

Further, despite the noteworthy progress in the field of SCM, it has still botched to deliver theory-driven justification or algorithms that may help to extract significant

insights from the huge amount of data. Several SC professionals have been attempting to regulate SC risks, which can hamper the SC in numerous ways. The steps for moderating such risks and avoiding disruption are an important memo for SC professionals. SC associated risks often lead to the stoppage of the operations activity for which it has always been a prerequisite to predict and avert such kind of situations. Further, some of the disruptive events like the devastating earthquake in Japan, the fire break in Meridian, remind us that we live in an unpredictable world. Recently the COVID-19 pandemic has shaken the whole world. The repercussions of these events have not only caused the loss of lives but have also severely affected businesses across industries and verticals (Ivanov et al. 2017). SC risk management and resilience have remained a viral topic of research from over the last two decades (Cavalcante et al. 2019; Panetto et al. 2019; Ivanov et al. 2019a; Ivanov, Dolgui, and Sokolov 2019b). Dubey et al. (2019d) discussed the role of DA in improving SC resilience and competitive benefits. Recently, Ivanov and Dolgui (2020) conceptualised the digital SC twin and edifies regarding the right point to integrate DA towards managing the disruption risks of the SC. BDA is a potent tool that can be

used efficiently to solve questions related to operations and SC risk. However, Wamba et al. (2020) concluded that surely BDA can assist in improving the SC functioning and performance but these effects rely on the level of environmental dynamism. Increasing use of the internet, customary enterprise resource planning (ERP) schemes, blockchain, etc. has assisted the companies to share real-time details to lessen the transaction duration, information imprecision, and idleness. Dolgui et al. (2020a) developed a blockchain-oriented dynamic model for smart contract design in the SC. However, owing to network complexity, consumers' variety seeking, and SC efficacy, envisaging and handling such risks in real-time are problematic. Nonetheless, BDA can be used not only to forecast and prevent the risks but also to shape innovative possessions, which can deliver strategic benefits and sustainability to the SC. The application of BDA on an assembly of such abundant data groups can nurture a positive conclusion-making tactic for envisaging quintessential prospects along with challenges related to SCM. Big data (BD) explains a way of assembling, regulating, and interpreting the huge extent of data sets. BD was primarily described in terms of volume, velocity, and variety (Arunachalam, Kumar, and Kawalek 2018). In order to handle the vast amount of data, the latest architectural designs are often required and desired. Traditional architectural components such as SQL databases are unable to handle the vast amounts of data and are obsolete at times. Today, customisation of the supply chain visibility (SCV) is one of the essential advancements in SCM (Awwad et al. 2018). SCV is an intricate glitch due to the interface between associated people, processes, tools, and information flow. SCM requires new resolutions and tools owing to the growing complexity. Current solutions and IT structures are unable to address this issue on time. Consequently, the latest solutions are established with the progress of the time. Also, with the progress of science and technology, data generated is growing at a rapid rate related to every facet linked with SCM (Columbus 2015). Data flow is recognised with physical forms until the application of information technology in SCM emerged. Presently, a prominent amount of information drift associated with the material drift is being presented as numerical or digitally structured data (Benabdellah et al. 2016). As the possibility linked to the SC has been increasing globally, the amount of data harvested from its various applications as well as the frequency at which it is being created can be authorised as BD. In addition to this, sales and marketing nowadays rely on the examination of the structured data laterally with the unstructured data to acquire an improved understanding of the client's desires and progress on the cost features of SC methods. The application of BD

can provide substantial growth and development in the prime most sectors such as, market demand predictions, development of the product, distribution optimisation, providing decisions, and client's feedback (Nguyen et al. 2018).

Hurwitz et al. (2013) defined BDA as 'the capability to manage and analyze petabytes of data enable companies to deal with clusters of information that could have an impact on the business.' According to Arunachalam, Kumar, and Kawalek (2018) the BDA in terms of SCM is best described as 'the ability of organisations to collect and organise SC data from heterogeneous systems distributed across organisational boundaries, analyze it either batch-wise or real-time or near real-time and visualise it intuitively to create proactive SC system and support decision making'. Wang, Kung, and Byrd (2018) defined BDA in the context of healthcare as 'the ability to acquire, store, process and analyze a large amount of health data in various forms, and deliver meaningful information to users that allow them to discover business values and insights in a timely fashion.' Certainly, BDA is a research trendsetter (Waller and Fawcett 2013a, 2013b).

SCM has been facing complex problems that can potentially lead to efficiency and waste in SC, such as delaying supplies, increasing fuel costs and customers' expectations, and inconsistent suppliers. BDA in SCM has raised the attention of practitioners as well as researchers, due to its outstanding role in SCM that promises to enhance the overall business performance. BDA examines the large amounts of data to discover hidden patterns, correlations, and other ideas. With the latest technology, one can analyze the data and get answers almost immediately. The prime objective of the BDA is cost reduction with the help of BDA technologies Hadoop and cloud-based analytics. It enables faster and better decision making for any organisation. The ability to measure customer needs and satisfaction through BDA can provide customers with what they want. BDA makes use of the data and quantitative methods to enhance the decision-making for all activities across the SC.

According to an Accenture survey (2014), more than one-third of respondents asserted that they had participated in serious discussions about the introduction of analytics in SCM while three out of ten already have the initiative to carry out analytics. Therefore, companies have been planning to use the BDA in logistics and SCM to increase transparency, flexibility, and integration of global SCs and logistics processes to effectively manage demand fluctuations and manage the cost. Recent research in the field of BDA has developed tools and techniques for creating data-driven SC systems. Real-time analysis and interpretation of results can help companies

to make better and faster decisions on customer requests. BDA technologies not only process large amounts of data but also effectively manage various types of data such as customer feedback, online blogs, social site data, etc. (Mortenson, Doherty, and Robinson 2015). Wang et al. (2016) studied BDA in SCM and investigated some significant applications of the same. Arunachalam, Kumar, and Kawalek (2018) classified the issues and challenges in adopting BDA in SCM that can be summarised into two categories such as organizational and technical challenges. Time-consuming, behavioural issues, inadequate resources, security and privacy concerns, issues with investment, scarcity of skills, etc. are organizational challenges. On the other hand, data scalability, the sufficiency of data quality, scarcity of techniques and procedures, etc. are the technical challenges. In a nutshell, the current study is focussed to address the following research questions:

- Which database is used to perform the present data-intensive study and why?
- What is the significance of BDA in the field of SCM, LM, and IM?
- What are the current progress and achievements of this field?
- What are the current challenges while adopting BDA techniques in SCM, LM, and IM?

The remaining paper is prepared as follows: Section 2 presents the literature review, Section 3 presents the research methodology for performing material collection, descriptive analysis, category selection, and material evaluation. Section 4 gives a detailed analysis of BDA with consideration of its domains which will give an idea to the readers regarding the most contributed author, journal, and country in the field. Section 5 gives a brief discussion concerning the proposed research questions. Section 6 defines the managerial implications and Section 7 concludes the study. Section 8 presents the limitations and future research directions of the study. It is hoped that this research will bring several advantages to the readers, researchers, Editorial Board of the journals, as well as the practitioners who are active in this field.

2. Literature review

The use of BDA is not new in the field of SCM and inventory, but it has evolved as an enabler for competitive advantages. Nowadays, analytics is being used for demand planning and forecasting to manage logistics operations with past data. The importance of BD for businesses and decision-makers has more to do with the eminence and analysis of the data rather than its raw

amount. Sufficient data can be used to help businesses troubleshoot failures, predict future system problems, generate information on customers at the point of sale to help elevate their experience, and help businesses create strategies for time and cost reduction efforts. All of this is based on the ability to sort data and look for patterns and other insights.

Nowadays, BDA plays a vital part in the field of marketing or promotions via social media platforms. BDA has targeted the best-fitted audience for any product marketing with the data compilation based on the clicks made on the web portal by an individual. Marketing or promotions in the form of social media or other channel scan help industrialists to better understand the role of smart technologies. Chae (2015) used the BDA in the SC tweets to show that the marketing or promotions via twitter hash tags have been increasing exponentially worldwide. The survey of tweets in the hash tags SC shows that Twitter is widely used for stakeholder participation, business promotion, and contracts. The study also provides the potential role of Twitter in SC practices with information such as business networks, stakeholder engagement, demand generation, new product/service development, and business management. Schoenherr and Speier-Pero (2015) conducted the first academic survey on the SCM predictive analytics (PA) and this study identified the primary benefits and obstacles to SCM PA. Similarly, this study also provided additional information about the different user groups and tried to explain the current state of the data science and BD in SCM.

Zhong et al. (2016a) studied the BD for the SCM in the manufacturing and service sector and discussed the current problems and future perspectives. Zhong et al. (2017a) reviewed the key technologies of the BDA such as the Internet of Things (IoT) and Information and Communications technologies that are very useful for intelligent manufacturing and also discussed the current problems and future directions. Ivanov (2017) presented a SC model with capacity disruptions and BD. In the same year, Kache and Seuring (2017) studied the emergence of BDA from the perspective of corporate and SC.

In recent years, smart manufacturing has gained more attention in the field of science and technology. BD provides an economical advantage for the smart manufacturing industry to be sustainable in the market (Ren et al. 2019). With the growing attention towards BDA, Industry 4.0 and smart manufacturing has become increasingly important for the progress of modern industry and business. Intelligent manufacturing can be seen as an important prospect for both research and application as it adds value to various products and systems through the application of advanced technologies to traditional manufacturing and service products. Ivanov et al. (2019a)

contributed to this by studying the effect of digitalisation and industry 4.0 on the ripple effect and disruption risk control analytics in the SC. A combined study of simulation, optimization, and DA are studied by Ivanov, Dolgui, and Sokolov (2019b) by combining the results gained from two isolated areas viz. the effect of digitalization on SCM and managing the ripple effect in the SC. Later in the year, Dolgui, Ivanov, and Rozhkov (2020b) performed a simulation-based study to study the relationship between the ripple effect and the bullwhip effect.

Foster et al. (2018) carried out a multi-facility, multi-year study of physician performance by leveraging BD from an emergency physician management network. Dubey et al. (2019a) studied the role of BDA in the Humanitarian SC with the consideration of trust and collaborative performance in the civil and military organizations. Professionals need to understand numerous logistical challenges of disaster relief that create interoperability and redundancy issues.

Govindan et al. (2018) explored the applications and opportunities of BDA in SCM and LM with the consideration of Scopus data. Addo-Tenkorang and Helo (2016), Tiwari, Wee, and Daryanto (2018), and Chehbi-Gamoura et al. (2020) investigated BDA and its application in SCM based on the Harzing Perish or Publish software (HP/PS) database. Gunasekaran et al. (2017) studied BD and predictive analytics for the performance of different business values. Song et al. (2017) studied how BDA supports societal development. The researchers summarized 14 papers for analyzing the effect of carbon emission in both its negative and positive effects. BDA helps researchers and practitioners to understand the dynamic changes of natural resources. Choi, Wallace, and Wang (2018) studied the effect of BDA in Operations Management and proposed various strategies to deal with the computational and data challenges.

Manufacturing and service companies have been constantly improving their processes to progress operational performance. Gupta, Modgil, and Gunasekaran (2019) investigated the existing literature of the BDA and lean six sigma to give assured and predictable decisions in the manufacturing and service sector. Dubey et al. (2019b) investigated the effect of BDA and predictive analytics on social performance and environmental performance based on 205 samples of Indian manufacturing companies by considering variance-based structural equation modelling. BDA is one of the most important technology for smart manufacturing, which can reveal hidden and other useful information that can play a vital role for the decision-makers in a competitive business environment. Hazen et al. (2018) attempted the misalignment between the practitioners of Operations Research

(OR) and further examined both the scholarly as well as applied applications of OR based on the BDA tools. The present paper suggests that OR can be used in solving the BDA problems in the field of SCM, LM, and IM. Table 1 summarises the previous literature review studies based on the search keywords, source of the database, period, publisher's name, and the number of papers selected for performing the review study. This gives a clear idea of work done, time-taken, the number of papers used, and the software/database used.

From Table 1, it can be seen that there exist many review papers that have considered the concept of BDA in SCM in different periods with different databases. However, the existing studies have not considered the articles of SCIE journals which can be seen as a major shortcoming in terms of the quality characteristic of the review been conducted. Moreover, the core areas of the SCM which is LM and IM have been missing in the existing literature. WoS is a unifying research tool that presents an effective interaction with the database in a timely fashion. None of the aforementioned researchers have considered the WoS database for carrying out the review of BDA in SCM, LM, and IM. Thus, despite having copious research in this area, there is a significant need to fulfil the above-mentioned research gaps.

3. Research methodology

Research Methodology is a necessary aspect of the literature review of an article. With the help of a literature review, it is easy to identify the conceptual content of the research area. According to Mayring (2003), Research Methodology includes the four essential steps for the systematic review, namely material collection, descriptive analysis, category selection, and material evaluation. A summary of the Research Methodology has been presented in Figure 1 describing each step through a flowchart.

3.1. Material collection

The first step of the literature review is material collection. This study considers only papers written in English and published in peer-reviewed journals with the date range. The web search WoS was used to manage the scientific publication data from 2015 to 2019 (02 August 2019), which contain the keywords 'Big data analytics' with 'Supply chain management' or 'Logistics Management' or 'Inventory Management' for the study. The database of WoS allows individual researchers to present a remarkable work for the effect of the research to its best advantage. For this study, 260 articles have been collected for reviewing and examining the details of various journals,

Table 1. BDA review articles in SCM/LM with consideration of different Database.

Authors	Title	Source of Database/ Software	Search Keywords	Publisher	Time-Period	Number of Papers selected for the study
Addo-Tenkorang and Helo (2016)	'Big data applications in operations/supply-chain management: A literature review'	(HP/PS)	BDA and SCM	Elsevier	2008–2016	NA
Mishra et al. (2018)	'Big Data and supply chain management: a review and bibliometric analysis'	Scopus	BD and SC	Springer	2006–2015	286
Govindan et al. (2018)	'Big data analytics and application for logistics and supply chain management'	Scopus	BDA, SCM, and Logistics	Elsevier	2012–14 March 2018	313
Tiwari, Wee, and Daryanto (2018)	'Big data analytics in supply chain management between 2010 and 2016: Insights to industries'	(HP/PS)	BDA and SCM	Elsevier	2010–2016	NA
Nguyen et al. (2018)	'Big data analytics in supply chain management: A state-of-the-art literature review'	Multiple Data search (e.g. Science Direct, Emeralds, Scopus, etc.)	BDA and SCM	Elsevier	2011–2017*	88
Barbosa et al. (2018)	'Managing supply chain resources with Big Data Analytics: a systematic review'	WoS, EBSCO and Emerald Insight	big data' or 'analytics' or 'intelligence' and 'supply chain	Taylor & Francis	2005–2016	44
Camargo Fiorini et al. (2018)	'Management theory and big data literature: From a review to a research agenda'	Scopus	So many keywords of BDA	Elsevier	October 2017 (Range is not defined)	41
Ren et al. (2019)	'A comprehensive review of big data analytics throughout product lifecycle to support sustainable smart manufacturing: a framework, challenges, and future research directions'	Scopus	BD, BDA and Smart manufacturing string of SCM	Elsevier	26 April 2018 (Range of Search keywords is not defined)	147
Chehbi-Gamoura et al. (2020)	'Insights from big Data Analytics in supply chain management: an all-inclusive literature review using the SCOR model'	(HP/PS)	BDA and SCM	Taylor & Francis	2001–20 February 2018	93
Kamble and Gunasekaran (2020)	'Big data-driven supply chain performance measurement system: a review and framework for implementation'	Scopus	BDA and SCM	Taylor & Francis	Till 2018 but range is not defined	66

subject, as well as the most cited papers. Consequently, 205 papers of BDA with SCM, 101 papers of BDA with LM, and 24 papers of BDA with IM were identified. A final sample of 260 papers was obtained by obliterating the repetition of papers. Some of the papers lie upon different search results of the WoS. It is not feasible to study all the collected papers; therefore, the review focused on papers according to the research methodology and the necessity. The final count of 58 papers was finalised for the systematic and detailed review. Figure 2 gives a

better understanding of how the material collection has been done and the inclusion/exclusion criteria for all the collected articles.

Figure 3 shows how the 'search' keyword has been used in WoS. The first keyword 'Big Data Analytics' was conjoint with the 'Supply Chain Management' that yielded 205 documents. Similarly, 'Big Data Analytics' with 'Logistics Management' gave 101, whereas 'Big Data Analytics' with 'Inventory Management' gave 24 documents. The total number of papers was 330, adequate for

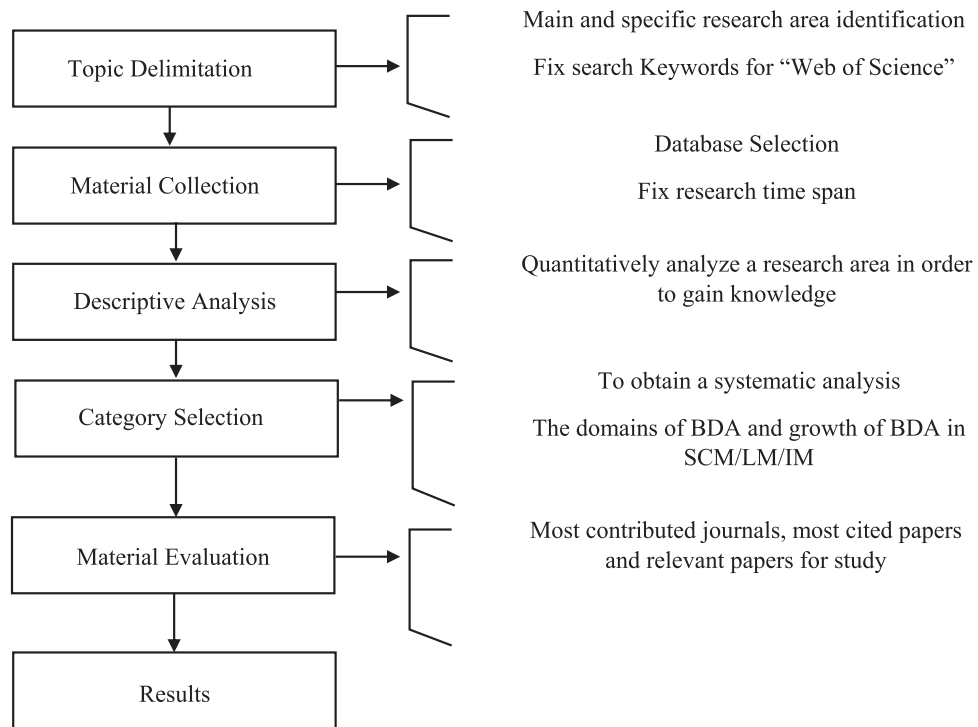


Figure 1. Summary of Research Methodology.

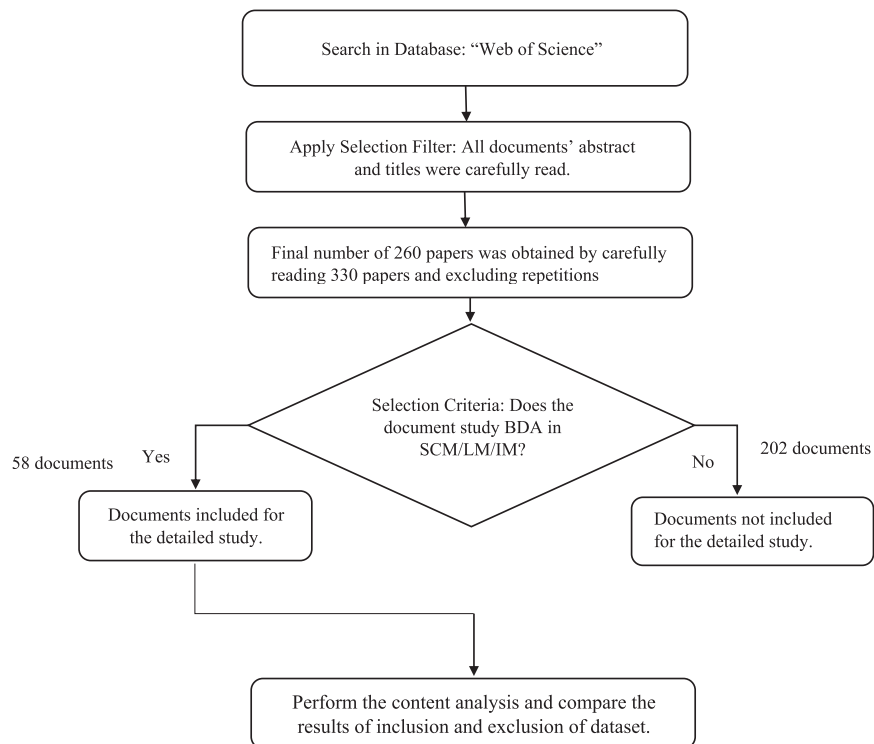


Figure 2. Data Collection and Selection for Evaluation.

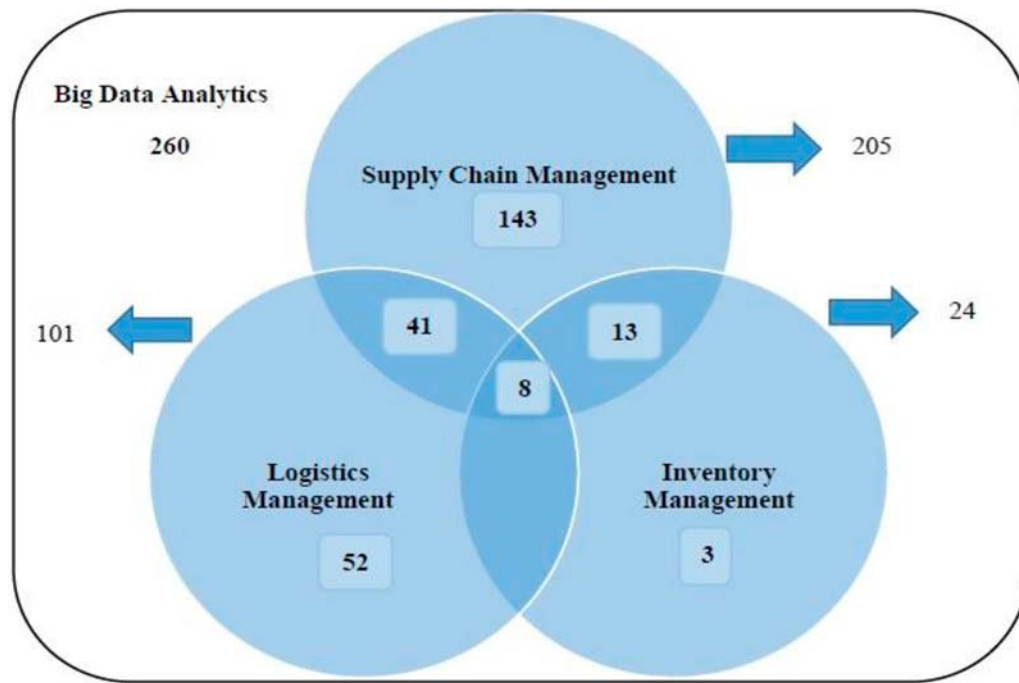


Figure 3. Representation of Total collection of Papers of BDA with SCM/LM/IM.

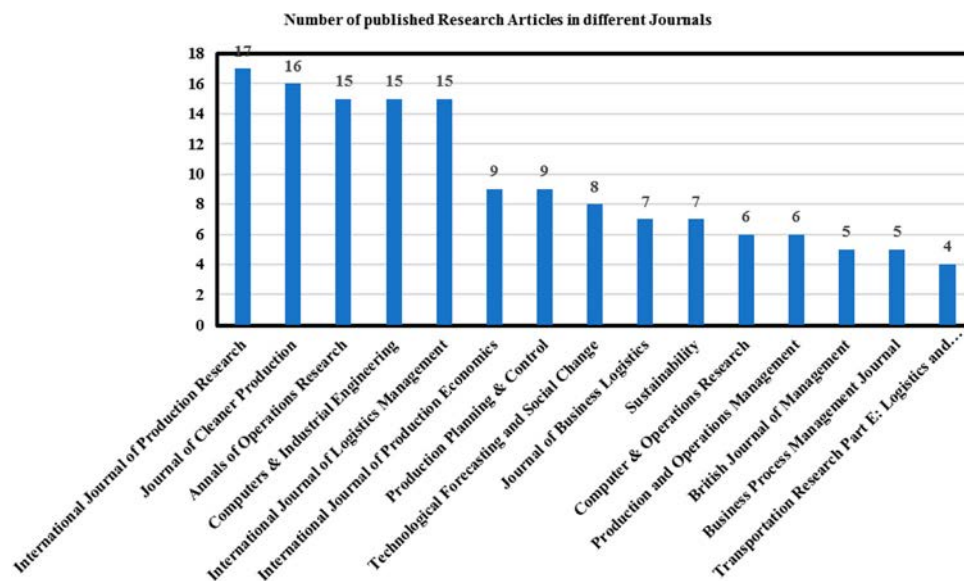


Figure 4. Articles exploring the effect of BDA in SCM, LM and IM during the year 2015–2019 (Top 15 most contributed journals).

the review, but we still carefully compiled these results and removed the repetition of the papers to obtain the final sample of 260 papers.

3.2. Descriptive analysis

The descriptive study and scientific research aim to quantitatively analyze a research area to gain knowledge on

how the discipline has evolved. The descriptive analysis gives an idea about the statistical analysis of the study. Figure 4 reveals that relevant articles appear most frequently in the International Journal of Production Research (IJPR), followed by the Journal of Cleaner Production (JCLP), Annals of Operations Research (ANOR), Computers & Industrial Engineering (CAIE), and International Journal of Logistics Management (IJLM), all

being well-established leading journals of this field based on search database. Figure 4 shows that the number of papers exploring BDA under SCM, LM, and IM has increased lately. It further demonstrates the final number of articles selected for the detailed study, which makes it different from the existing literature, which is based on the Mayring (2003) methodologies.

The distribution of selected journals has been shown in Figure 4, which reveals the attention of the researchers and the Editorial Board members. After the compilation of the result, it has been found that IJPR has been the most contributed journal in the field of BDA in SCM, LM, and IM during the last five years having published 17 articles. Further, based on this categorisation, the contribution of the other journals cannot be ignored. The study, therefore, takes into consideration 15 of the most contributed journals in the BDA with SCM, LM, and IM.

The study of BDA in SCM, LM, and IM has increased exponentially. In 2015, only 15 articles were published with the consideration of these keywords, subsequently, in 2016, 2017, and 2018 the number of published articles rose to 28, 53, and 97 respectively. In the year 2019, (till 02/08/2019), 67 articles have been published. Figure 5 shows the distribution of the numbers of articles published during the year 2015–2019*. Therefore, it can be said that the attention of the researchers has been increased exponentially.

3.3. Category selection

The selected papers have been classified into various ‘categories’ to obtain a systematic analysis. The major categorization is by ‘links’ growth of BDA in SCM (Section 4.4) and domains of BDA in SCM (Section 4.5). To obtain a deep understanding of BDA in SCM/LM/IM have been used to decisions and what are the main domains of BDA

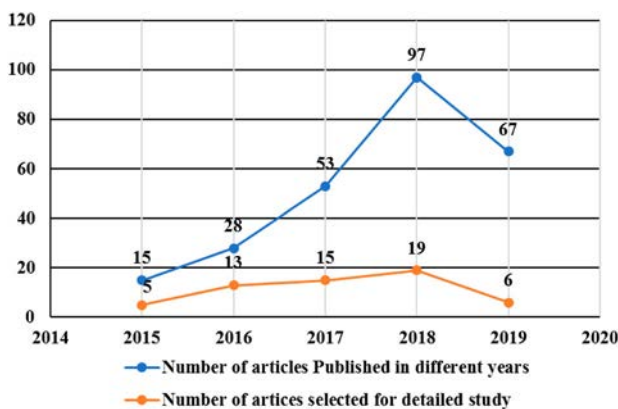


Figure 5. Distribution of published articles during the year 2015–2019.

in the field of SCM/LM/IM which are treated for the decision process. The final selection for the inclusion of the paper has been done by category selection after carefully considering the title, abstract, and keywords of the papers.

3.4. Material evaluation

The present review study ensures that the publications are adequate and appropriate for material evaluation. For the material evaluation, Appendix C gives the idea about the most contributed publications during the 2015–2019 (02 August 2019) based on the number of citations. This study considers the publications with at least 20 or more citations. If we had considered articles with 5 or 10 citations then it would have been tough to analyze each paper in this short study. Therefore, the papers with 20 citations are considered and this is the limitation of this study. However, we still considered some articles which do not lie in this criterion to perform a scientific analysis of the study. From the collection of data, 36 publications have at least 20 or more citations according to the WoS database. The other relevant documents which do not lie in this category, are explored in Appendix A. Eminent academicians and researchers have explored the opportunities of various methodologies and approaches used in BDA in the field of SCM//LM/IM.

If we talk about the classification of data on the subject basis, 84 articles were purely based on Operations Research, 61 in Industrial Engineering, and 61 in Management category from the WoS database. Figure 6 shows the distribution of the published papers based on different subjects with the search category. Some articles are common for many subjects for these keywords. From Figure 6 it can be said that the greatest number of published articles is in the field of Operations Research, i.e. 84, and the said classification is based on the total number of papers i.e. 260.

4. Detailed analysis of BDA

This section will discuss the comprehensive study of the BDA in the field of SCM/LM/IM with the consideration of some of the most contributed authors and industries of this field. Section 4.1 represents the five important V's of BDA which is essential for the content analysis. It also discusses the DA and difference between Data Science & DA. Section 4.2 is for the content analysis, Section 4.3 investigates the general trends of authors and country in this field, section 4.4 gives the idea about the growth of BDA in SCM and Logistics Operations while the last section 4.5 investigates the domains of the BDA in SCM/LM/IM.

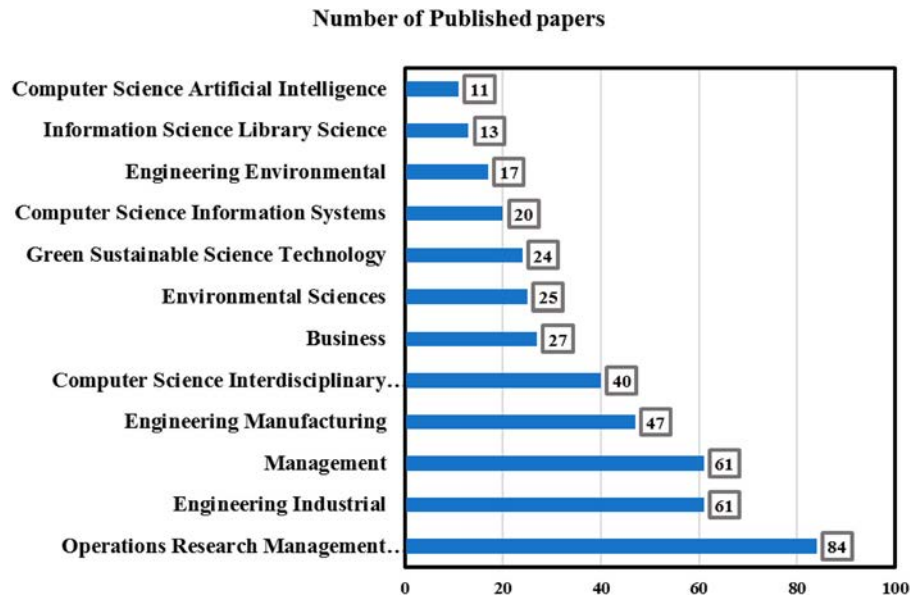


Figure 6. Distribution of Publications with Keywords in Different Subjects.

4.1. Five important V's of BDA and DA

The basic query that arises is related to the content generation. The BDA has five crucial V's which are coined as 'Volume', 'Velocity', 'Variety', 'Veracity', and 'Value'. The role of these five is to generate and analyze the data. Manyika (2011) defined BDA as, 'Big data refers to datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyze.' Earlier there were only three V's that were used to describe BDA namely, 'Volume, Velocity, and Variety' (Manyika 2011; Sonka 2014). The other two aspects viz. Veracity and Value were explored by Manyika 2011; Neaga et al. 2015 and Ge and Jackson 2014. The volume in BDA refers to the magnitude of the generated data and the variety is related to the structural heterogeneity in the dataset (Gandomi and Haider 2015). The speed of the generated data is coined as velocity (Gandomi and Haider 2015). The term 'Veracity' is connected with the confirmation of the data quality and with the verification of the uncertain data. The last term 'Value' imparts the economic benefits of the BDA.

Another most important thing about BDA is to understand the basic concepts of DA. In this section, the different types of DA, as well as the difference between Data Science and DA, have been presented.

4.1.1. Types of DA

Basically, there are two types of DA – the first type of DA shows the past trends, and the second type shows future trends with the help of the first one. These two types of DA further classified into two types. The different types of DA are as follows:

4.1.1.1. Descriptive analytics. It provides insight into past trends. This type of analytical technique uses data aggregation and data mining to provide insight into the past and answer: 'What has happened?' It also summarizes the data in a meaningful way.

4.1.1.2. Diagnostics analytics. It is the examination of data to answer the question 'Why did it happen?' it takes a more in-depth look at the data to attempt to understand the causes of events and behaviours and is characterised by techniques such as Drill-down, Data Discovery, and Data Mining and Correlations.

4.1.1.3. Predictive analytics. It uses statistical models and forecasts techniques to understand the future and answer: 'What could happen?' It is important to remember that no statistical algorithm can 'predict' the future with 100% certainty. Predictive analytics can be used throughout the organization, from forecasting customer behavior and purchasing patterns to identifying trends in sales activities.

4.1.1.4. Prescriptive analytics. It uses the optimization and simulation algorithms to advise on possible outcomes and answers: 'What should we do?'

Figure 7 shows the representation of different types of DA. Some of the past literature studies did not consider Diagnostics Analysis. On the other hand, it is essential analytics for the review of the future perspective. It gives the idea about the previous process 'why did it happen?' This feature provides advantages to the analyst for better performance in the next task and also gives an idea about

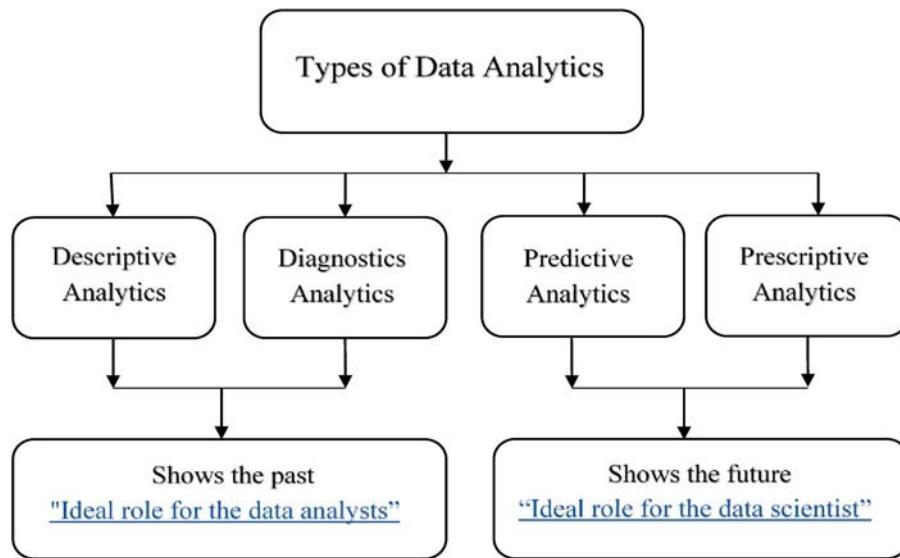


Figure 7. Types of Data Analytics.

what to do and what not to do to enhance performance. So, the role of Diagnostics Analytics cannot be ignored.

4.2. Content analysis

Content analysis is best understood as a broad family of techniques that grants a procedure that can be used to evaluate a large amount of data systematically. It is a necessary step to recognise various topics covered by the study and to give a clear indication of the areas requiring further investigation. The present study is benefitted from the content analysis by having found some major technical issues and challenges in the field of BDA in SCM, a detailed study of the 58 research articles is represented in Appendix B. Certainly, privacy and security are the basic features of an organization and some organizations still suffer from these issues. Lack of skilled analysts is another critical challenge towards handling the extensive data set of any organization. Some other challenges include data scalability, data quality, and lack of techniques and procedures. Richey et al. (2016) identified that data scalability is the major issue in adopting the BDA in the SCM. Moreover, from Appendix D it is observed that numerous studies focused on the applications of BDA in SCM for demand forecasting, production planning and control, scheduling, logistics, IM, SC resilience, and risk analysis. However, some prominent fields of SCM such as sustainability, closed-loop supply chain (CLSC), supplier selection problems, reverse logistics, reliable SC through Internet of things (IoT), etc. are yet to be explored under BDA environment. Demand forecasting is a challenging task for SC executives. Once a company has enough information about their consumers' behavior, they can

have a better understanding of demand variations in the future. The policymakers can forecast demand through BDA (Hamister, Magazine, and Polak 2018; Hofmann and Rutschmann 2018). The researchers have been paying more interest in production planning and control through BDA applications and tools. (Zhong et al. 2015; Dubey et al. 2019d). Although the frequency of introducing BDA in product development and the diagnosis and maintenance of equipment is relatively low, articles in this field have made significant contributions to predictive and prescriptive analytics research (Lei and Moon 2015; Wang et al. 2016; Wang and Zhang 2016; Zhang et al. 2017). Risks and uncertainties are associated with every action. Every business entails the evaluation of risk factors, where some risks are fore see able while others are not. BDA provides SC with risk mitigation abilities (Aker and Wamba 2016; Papadopoulos et al. 2017b). There is an urgent need for the SCs to be aligned with the transforming consumer preferences to enable the facility of sustainable products and logistics. Through this study, it has been analyzed that less attention is given to BDA practices in areas like sustainability, CLSC, supplier selection problems, reliable SC through the Internet of things (IoT). These are the core areas of SC and valuable research in these dimensions will indeed fetch the overall benefit of the value chain and SC.

4.3. General trends of BDA

The data has been collected with the help of WoS through the topic search during the last five years, i.e. 2015–2019 (02/08/2019). The WoS database gives more relevant results as compared to other search software or websites

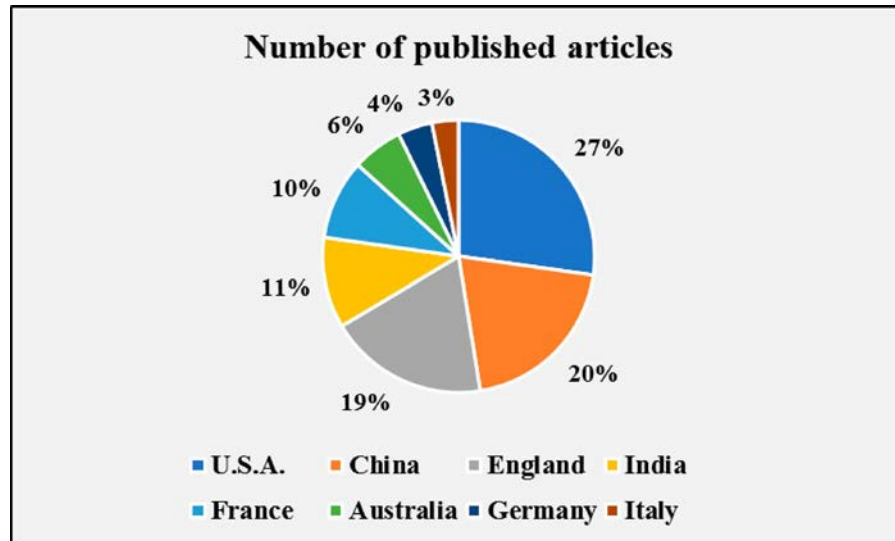


Figure 8. BDA Published Articles with the Consideration of Different Countries.

(Li, Rollins, and Yan 2018) which is why it has been preferred for this study. The data has been collected on 02/08/2019 at 02:00 PM with different search keywords such as 'Big Data Analytics' with 'Supply Chain Management', and 'Logistics Management' and 'Inventory Management'.

The section considered the country that contributed the most based on the published articles. It has been seen (Figure 8) that the authors from the USA have published more articles in this field. The second in line is CHINA, third ENGLAND and the fourth is INDIA. The most contributed country was considered based on the author's affiliation. It has also been seen that there are many authors whose parent country was different from the current working parent country. Therefore, only the author's institutional country has been considered.

Figure 9 shows the most contributed authors in the field of BDA in SCM, LM, and IM. Gunasekaran is the most contributed author of this field during the year 2015–2019. The current study considers works by the sole author or co-authored works. Gunasekaran published 22 articles of this area in the last five years as an author or co-author. The second most contributed author is Dubey, the third Papadopoulos, and fourth is Wamba, etc. The top 15 most contributed authors are shown in Figure 9.

This study gives the idea about the most contributed author, journal, the country as well as others' contributions in the field of BDA in SCM, LM, and IM. This study will be helpful for the academicians, researchers, practitioners, and young learners in the field of BDA in SCM/LM/IM.

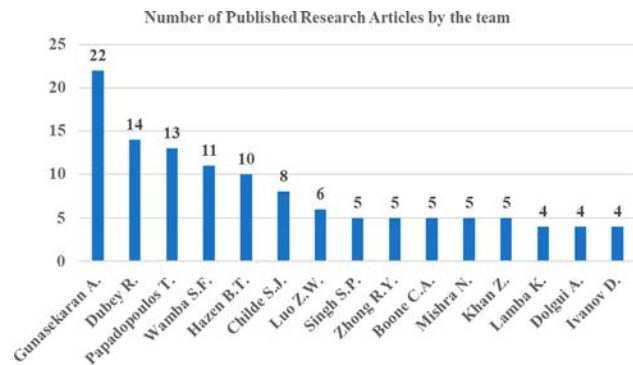


Figure 9. Most Contributed Authors that Explored BDA in SCM, LM, and IM.

4.4. The growth of BDA in SCM and logistics operations

BDA uses the data and quantitative methods in all the activities of the SC. Particularly, it conducts two new things which are an expansion of the dataset for analysis beyond the traditional internal data help in ERP and SCM systems. And, it adopts powerful statistical techniques from new and existing data sources. This enables new implications that assist in improving the overall SC decision making.

Global SC, economic uncertainty, scrutiny regulations, and dynamic product life cycles are the operational trends of BDA. Maturity in the role of analytics is the proliferation of data, cloud computing, easy to use tools, infrastructure, and automation. More organizations or more companies would want analytics to be delivered as a platform or a solution to a proper user interface. The

most common areas of logistics and SCM where BDA can be used in product cost management, demand planning, and supply management, end-to-end SC visibility, margin improvement, risk management, productivity, and asset efficiency.

The question that arises is as to why BDA is so important in SCM and logistics operations. The answer is that it optimizes business operations by analyzing customer-behavior. Amazon, Flipkart and other online web portals are using our clickstream and past purchase data. More than 300 million customers have signed up for Amazon; they analyze data of all the users, items they view, and how they navigate through their site.

The problem of vehicle routing and scheduling has been using the applications of the analytics and this, in turn, optimizes the operational requirements from the inventory. Even though they lag in terms of marketing, logistics and operational applications have become more complex. BD without analytics is just a large amount of data and the analytics without BD are simply mathematical/statistical tools and applications. As Google's Director of Research Peter Norvig noted: 'We don't have better algorithms, we just have more data'. However, this is only partially true. The availability of BD and advances in Artificial Intelligence (AI) have evolved significant new possibilities for the development of the algorithm and datasets.

4.5. Domains of SCM using BDA

Figure 10 represents the leading sector of SCM in which the technique of BDA can be used for advancement. Education, Finance, Governance, Healthcare, Retail, and Telecom, etc. are the fields in which the use of BDA has been increasing and it provides the optimal solution in a competitive environment.

4.5.1. Education sector

In education, the pedagogical decisions made by a professor to measure a student's understanding of the material or organize the structure of a course may have the most significant impact on student learning and the rate of graduation. High-quality instruction may decrease the time a student takes to learn certain material, allow students to acquire more information in the same amount of time, and help students to make better decisions about what they should study. To ask the right questions, to make the best use of BD as a tool to support our decision making, educators and learners need to understand how DA can support the learning process. Three ways in which we can benefit from using BD is capitalising on its

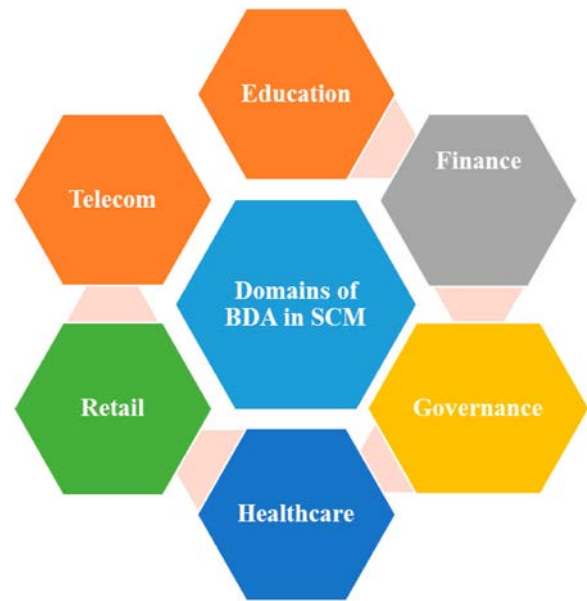


Figure 10. Key Domains of SCM using BDA.

ability to measure understanding, personalise the learning experience, and help in designing more interesting courses.

Through the BDA, educational institutes can measure, monitor, and react in real-time to students' understanding of the material. Analytics has shown how students learn, which will help educators in adapting their teaching style. This is an important development for teachers as it enhances their ability to engage students.

4.5.2. Finance (banking sector)

BDA in the banking and financial service sector creates a better customer experience and also protects the business. It can be the main driver of innovation in the banking sector, and it has surely become one. Here are some examples of BD uses in banking:

- **Fraud Detection:** In the area of Banking and Finance sector, fraud is prevalent in highly regulated areas. Analysis of the data is an integral part of BDA which detects the fraud in the financial sector and prevents it. With the advancement of analytics and machine learning techniques, fraud detection teams can detect fraud risks faster and more accurately.
- **Risk Analysis:** Another common problem in the financial sector is an appropriate understanding of risk. Many financial companies are committed to understanding the risk; insurance agencies need to be aware of how much risks they are taking while insuring a customer. On the other hand, investment firms need to understand the risks of the market and how much risk their customers are comfortable with. BDA

allows for this process to be faster and more accurate for better customer experience, as well as a lesser adverse experience for the banks.

- **Personalised Products:** BDA has provided a wealth of information to the companies. It is clear that with the consideration of BDA in financial and banking sectors they will be benefited by using this information to customise audience sets by demographic, behavior, etc. and offer the customers personalized products. Though it is to be known that not every product mortgage, savings account, stocks and bonds, investments, or loans will be a good fit for each and every customer. BDA means banks and financial institutions can be more specific about product offerings, likely increasing the chance that the right product will be offered to the right person.

4.5.3. Governance

One of the main advantages of BDA is its flexibility and universal applicability indifferent sectors. As in many other areas, BDA can have a significant impact on the government's role at local, national, and global levels. Given the many complex issues on the table today, governments must do their utmost to understand the information they receive and make important decisions that benefit millions of people. The information collected by the help of BDA is not only difficult to verify all the information but also sometimes is difficult to check the actual situation of the information itself. Faulty datasets can have terrible consequences for the government that will affect the welfare schemes of society.

4.5.4. Healthcare

BDA has changed the environment of the healthcare sector by managing and analyzing the data. Health care is one of the most promising areas in which BDA can be used. Health analysis can potentially reduce health care costs, predict epidemics, prevent preventable diseases, and often improve quality of life. The average life expectancy of human beings has increased worldwide, introducing new treatments and new challenges. Healthcare professionals, such as entrepreneurs collect large amounts of data and find the best strategies by using these numbers. BDA is a large amount of information created by digitisation of the processes, and it analyzes and integrates the specific technologies by using the data. The application of BDA in healthcare has gained a lot of positive and life-saving effects.

4.5.5. Retail

In 2019, customers expected personalisation. They wanted a smooth experience between online and physical stores. If they could not buy it quickly, they would go

to another vendor. BDA can resolve these difficulties for vendors who want to increase sales and consumer satisfaction. Loyalty programmes are one of the most common ways to collect large amounts of retail data. Today, it also captures credit card transactions, IP addresses, user logins, and more. As more and more information is collected, retailers can analyze the ups and downs of previous consumer purchases and pricing to predict future costs and make personalized recommendations. Amazon uses BDA based on the search queries and previously purchased items. The company produced 29% of its sales through the recommendation engine which analyzed more than 150 million accounts. This has brought considerable profits to the e-commerce giant. For retailers, BDA offers the opportunity to provide a better customer experience. Costco uses its data collection to keep its customers healthy.

4.5.6. Telecom

The global telecommunications sector has found itself in an extremely complex environment of lower profit margins and a saturated network. To survive and compete with their competitors, telecom companies have begun to introduce BDA. A recent study of IBM's shows how telecom sectors have been utilising the BDA that considers the 85% of respondent's information which can create a competitive advantage. BDA initiative is designed to drive growth in telecommunications by improving efficiency and profitability.

BDA can enhance the service and impact by examining network traffic and call records. It can improve the quality of service and traffic routing problems more efficiently. By analyzing call records in real-time, telecom operators can detect fraud and react immediately. Marketing departments can customize their activities to better engage their customers and leverage the knowledge gained to develop new products and services.

5. Discussion

Data drives every sphere of the world, be it economy, growth, or overall productivity. And, with the growing advancements in the field of Science and Technology, the data has turned massive and hard to interpret. Here, the BDA comes in picture with the ability to retrieve the large and varied data to uncover the hidden trends, indefinite correlations, market patterns, and consumer choices. The role of BDA in the SC, inventory, and logistics management is of utmost significance in extracting the information of not only physical flows but also financial flows. The present paper reviewed literature from the year 2015–2019 and highlighted the prominence of BDA in SCM, LM, and IM through the analysis of 58 papers.

The answer to the research questions posed at the beginning of the paper have been summarized subsequently.

The WoS database covers only the journals of influence and it has been used in academic studies from around 20 years. Thus, we have chosen the WoS database to conduct this study. Moving on to BDA and its significance in the field of SCM, LM, and IM; the prime reason behind why SCM, LM, and IM are so appealing is because of the incredible breadth of what these fields are and what they encompass. With the recent trends in digital technology, SCM, LM, and IM are on the cusp of notable changes. Technologies such as IoT, AI, Blockchain, Predictive Analytics, Autonomous processes have brought revolutionary transformations which indeed calls for holistic and high-level decisions to drive the business forward. The BDA assists the decision-makers in extracting useful insights from the enormous data accrued by various operations in the business. BDA indeed brings transparency among the SC players and acts as a catalyst towards efficient management of the overall SC.

Further, the current progress in the field has been analyzed through a systematic review of 58 papers from which it is concluded that the adoption of BDA in the SC helps in improving customer service. The decision-makers can take quick action on SC glitches which increases SC overall productivity. The BDA helps in interpreting hidden information through which the managers are able to identify who is collaborating with whom, mitigate the bullwhip effect, analyze consumer behaviors, risk and performance metrics, etc. However, despite these signs of progress, the field has still been facing some major challenges. To better predict the customer requirements, better assessment of the SC risk, improvement in SC traceability, better-coping abilities with the demand volatility, and managing cost fluctuations are some of the prime challenges being faced by the SC executives. Also, regardless of the overall potential of the BDA, there is a prominent need for data sharing by the organizations involved in the SC in a collaborative way.

6. Implications

BDA is being utilised in every aspect of the SCM, LM, and IM. Through this review, the significance, opportunities, and challenges of BDA in SCM, LM, and IM have been analyzed. The prime revelation suggests that the implementation of BDA is without a doubt beneficial for the organization but the optimal strategies to apply the BDA techniques is yet to be explored. There is a lot of scope in the field of BDA with consideration of the advancement of technology. Further, emphasis should be given to the adoption of BDA in a variety of SCM such as finance,

banking, health care, and other industries. However, the collaborative practices taking into account all the stakeholders of the SC are a much-required initiative for the efficient implementation of BDA techniques in the SC. Moreover, standard strategies must be established to normalise the procedure of information flow and sharing among the SC players with a motto to enhance mutual benefits and better decision makings. Furthermore, there is a growing need to reduce irrelevant data at every time point. The huge data needs periodic audits to ensure that irrelevant data is not generated at the source (Rehman et al. 2016). For instance, the reviews and survey data can be streamlined to generate optimum data which is easy to handle and share. Such an approach will assist in reducing efforts and infrastructure costs. The main question of what to do and what not to do should be well tested while handling huge data. As SC institutions have become more complicated, data legacy issues have been emerging. There is a usual need to capture the business's legacy data consequently to have its intelligent application. Institutions must have a preventive check to identify and authenticate the source of data. SC enterprises must prevent the urge to build complicated models and ensure their priorities before acquiring any data. This will help them to cater to sound practice and good data governance which can be improved and developed by linking novel and diverse datasets to create smart business insights. Professionals dealing with BD are often referred to as data analysts; the data analyst's mindset is persistently self-critical and always interrogative. They should have the courage and wisdom to develop the confidence and authority to fight with the emerging doubts and should progress ahead while dealing with BDA related to SCM, LM, and IM. They should be able to see the world bottom-up and communicate top-down as they are guiding the process of change; which is somewhat machines will certainly not be able to do. SC institutions must set their priorities and recognize the most likely factors which can provide value to the SC business. SC institutions must identify the important processes, the example of user cases, novel data, and techniques for better understating and business suitability. For better upliftment of SC and related industries, there should be BD sharing to increase the comprehensiveness, enhance their offerings, and make a greater business value. To get the maximum benefits and information from the BD, the SCM organization needs to develop a test-and-learn culture. In this culture, older and experienced management sets the vision and other allied employees are encouraged to recognize the opportunity areas and work on those areas to analyses and deploy the data to interpret the results. This is essentially a learning process with no-blame culture, where SCM organizations have been looking for new and

possibly highly counterintuitive insights. If the hypothesis stands good, the SCM organization may work to implement and, if it doesn't work, this should be treated as a lesson for the subsequent attempts. Lastly, there is an urgent need to drive consensus on the authenticity of the data.

7. Conclusion

BD describes the huge multi-faceted data records, which cannot be analyzed with the help of conventional tools. The efficient management of such huge data using advanced scientific approaches is commonly termed as BDA. In today's era of BD, companies are overwhelmed with data garnered from both traditional and advanced sources such as social media platforms, third-party cloud platforms, IoT devices, business transactions, and many more. In SCM, the chief objective of the SC executives is to extract useful information from such multi-structured data. In present market dynamics, organizations are effectively applying BDA to adequately predict future trends in the data and achieve a competitive edge. Thus, BDA is stimulating the performance of the SC by expediting correct and timely decisions and holds the potential to outperform and transform traditional SCM, LM, and IM practices. This study considered 260 research papers based on BDA in SCM, LM, and IM through the web search on WoS. A conceptual research methodology framework has been developed for the different stages of the BDA. This paper focused on the original contributions of the authors who studied or summarized the BDA practices with consideration of SCM, LM, and IM.

The prime aim of this literature review is to provide an in-depth study of the significance of BDA in SCM, LM, and IM. It examines how the use of BDA is facilitating the performance and timely execution of logistics and SC. The advancement of BDA techniques has been demonstrated in the present research through a systematic and crisp review based on a recent period. The selected period for the review has a significant and increasing number of publications, through which the latest updates and advancements in the field are well analyzed. The findings and discussions have highlighted research gaps, old methodologies, and new methodologies to catalyse the research development of BDA and its applications. Managers can learn different methodologies, and approaches to effectively implement BDA in their SC. Future work should be focused upon ways to improve the proposed framework by considering a wider range of applications of BDA in the product lifecycle for sustainable production and cleaner production. The BDA techniques can be upgraded by posing more consideration to the production and procurement sectors. The individual managerial

efforts towards setting up the BDA infrastructure for the whole business is costly and time-consuming. Thus, it is the need of the hour that all the participants of the SC must work in alliance towards a viable setup of BDA which will indeed provide valuable information timely and would further aid in reducing high business costs.

8. Limitations and future research directions

The future research can be done in the direction of the organization and technical challenges of BDA in SCM. The major sectors for future research could be particularly from the domains of healthcare, retail, finance, education, telecom, governance, etc. Further, the methods of optimization in the field of BDA in SCM could be explored by adopting suitable methodologies. Moreover, in the process of SCM, there exists a multi-echelon for the functioning of the SC which is inter-related. Hence, fragmented efforts of BDA adoption to only one or two functions will not yield any significant and long-lasting competitive advantages. To avoid such fragmented efforts, the entire SC should be horizontally integrated by aligning BDA applications in different functions effectively, as alignment dissolves the boundary across functions. For example, production and logistics planning decisions could be connected with real-time demand sensing for cost reductions and higher service levels. Some of the key limitations and future research guidelines of the study are given below:

- The findings of this literature review study are focused on the collected data from the WoS with certainly considered inputs in the search option. In the future, the authors can explore other databases like Scopus, Emerald, Google Scholar, etc. and perform a process-oriented analysis to discuss the recent trends and advancements in the field of BDA.
- The period of the data collection is 2015–2019 (02 August 2019) and it is considered that it is the best representative data for this literature review study. Future works may extend the duration of the search period.
- Based on this review study, we recommend that future research can be implemented for a specific journal, domain, or industry in BDA with SCM, LM, and IM or other emerging fields.
- Also, other key technologies related to smart manufacturing could be investigated.

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Appendices

Appendix A

Table A1. Detailed Journals with Authors and Quantity of Articles

Journal	Quantity of Articles	Authors (Year)
International Journal of Production Research	7	Zhong et al. (2017b); Hofmann (2017); Gunasekaran et al. (2018); Raguseo and Vitari (2018); Winkelhaus and Grosse (2019); Yang, Lan, and Wang (2019); Kamble and Gunasekaran (2020)
International Journal of Logistics Management	6	Wamba et al. (2018); Lai, Sun, and Ren (2018); Hofmann and Rutschmann (2018); Gravili et al. (2018); Queiroz and Telles (2018); Lamba and Singh (2018)
Computers & Industrial Engineering	5	Zhong et al. (2016a); Addo-Tenkorang and Helo (2016); Hazen et al. (2016); Tiwari, Wee, and Daryanto (2018); Shukla, Tiwari, and Beydoun (2019)
International Journal of Production Economics	4	Chae (2015); Dutta and Bose (2015); Wang et al. (2016); Sheng, Amankwah-Amoah, and Wang (2017)
Annals of Operations Research	4	Mishra et al. (2018); Prasad, Zakaria, and Altay (2018); Malik, Abdallah, and Ala'raj (2018); Li, Rollins, and Yan (2018)
Journal of Cleaner Production	3	Papadopoulos et al. (2017a); Zhao et al. (2017); Seles et al. (2018)
Production Planning & Control	3	Lamba and Singh (2017); Shukla and Tiwari (2017); Papadopoulos et al. (2017b)
Technological Forecasting and Social Change	3	Roßmann et al. (2018); Yadegaridehkordi et al. (2018); Dubey et al. (2019b);
European Journal of Operational Research	2	Vidgen, Shaw, and Grant (2017); Grazia Speranza (2018)
Journal of Business Logistics	2	Schoenherr and Speier-Pero (2015); Hamister, Magazine, and Polak (2018)
International Journal of Advanced Manufacturing Technology	2	Dubey et al. (2016); Zhong et al. (2016b)
Sustainability	1	Mani et al. (2017)
Academic Emergency Medicine	1	Taylor et al. (2016)
Asia-pacific Journal of Operational Research	1	Xu et al. (2015)
California Management Review	1	Sanders (2016)
Engineering	1	Zhong et al. (2017a)
IEEE Access	1	Tawalbeh et al. (2016)
IEEE Transactions on Cybernetics	1	Choi, Chan, and Yue (2017)
International Journal of Information Management	1	Rehman et al. (2016)
International Journal of Operations & Production Management	1	Kache and Seuring (2017)
International Journal of Physical Distribution & Logistics Management	1	Richey et al. (2016)
Journal of Business Research	1	Gunasekaran et al. (2017)
Journal of Enterprise Information Management	1	Giannakis and Louis (2016)
Journal of Knowledge Management	1	Khan and Vorley (2017)
Journal of Management Information Systems	1	Chen, Preston, and Swink (2015)
Proceedings of the IEEE	1	Johnson et al. (2016)
Transportation Research Part E: Logistics and Transportation Review	1	Arunachalam, Kumar, and Kawalek (2018)
British Journal of Management	1	Dubey et al. (2019c)

Appendix B**Table B1.** The detailed study of the 58 sample papers.

Authors	Year	Citations	Study	Main Keyword other than BDA and SCM
Wang et al.	2016	260	This paper provides a review of the application of BDA in logistics and SCM.	Maturity model
Gunasekaran et al.	2017	147	This study considered the key role of predictive analytics in the BD for the SCM.	Assimilation, Routinisation, Adoption
Zhong et al.	2016a	128	This paper investigates BDA from typical services like finance & economics, healthcare, SCM, and the manufacturing sector.	Service Applications, Manufacturing Sector
Chae	2015	122	This paper studies the key role of social media in DA and SCM by considering twitter hashtags as content.	Content analytics, Social media analytics
Papadopoulos et al.	2017a	113	This study has gone through the 36,422 items gathered with the help of social networking sites such as Twitter, Facebook, Instagram, and YouTube, etc. via responses from 205 managers involved in the humanitarian relief chain aftermath of the Nepal earthquake in 2015.	Resilience, Disaster
Dubey et al.	2016	108	The paper shows the role of BDA in supporting world-class sustainable manufacturing (WCSM).	Social networking site, Sustainable manufacturing
Schoenherr and Speier-Pero	2015	97	The study gives insights into the rapidly evolving domain of SCM with BDA and it was also the first academic large-scale survey study in the given context.	Predictive analytics
Kache and Seuring	2017	82	The research investigates the potential impacts of BDA on information usage in a corporate and SC context.	Delphi study, Digital information
Zhong et al.	2017b	80	This study introduced BDA for RFID logistics data by defining different behaviors of smart manufacturing objects.	Radio frequency identification (RFID), logistics
Chen et al.	2015	79	This study draws the dynamic capabilities to conceptualise the use of BDA as unique information processing to the organizations to take competitive advantages.	Survey research
Dutta and Bose	2015	75	This research discusses a holistic approach for the implementation of the BD project and validates it through a descriptive study of a cement limited.	Cement industry, Outbound logistics
Zhao et al.	2017	75	The study proposes a multi-objective optimization model that minimises the risk associated with the handling of hazardous materials, related carbon emission, and economic cost with consideration BDA.	Carbon emissions, green supply chain management
Addo-Tenkorang, and Helo	2016	75	A review that explores the trends and perspectives of BDA in SCM.	Internet of Things (IoT),
Rehman et al.	2016	71	This paper presents a business model for data reduction in enterprise applications. The primary goal of this study is to maintain the trust between the customers and the enterprises with consideration of the privacy of the customers.	Sustainable enterprises, Business model
Choi et al.	2017	66	This study examines the technological development and advances for industrial-based business systems, the reliability and security of industrial systems, and their operational risk management.	Business Intelligence (BI), systems reliability and security
Tiwari et al.	2018	61	This paper investigates BDA research and application in SCM between 2010 and 2016 and provides insights into industries.	Big data application
Hazen et al.	2016	53	This article reviews eight theories that can be used by researchers to examine and clarify the nature of Big Data and Predictive Analytics' impact on SC sustainability.	Predictive analytics
Choi et al.	2018	51	This study explored the existing BD related analytics techniques, and identify their strengths, weaknesses as well as major functionalities.	Data-driven optimization; applications and case studies
Sheng et al.	2017	45	The study provides an overview of the BD research in the management domain and presented insights from 285 articles. By classifying and analyzing the identified literature, the present paper clarifies several perspectives of management communities and offers a clearer picture of the status of BD research.	Management research Literature review
Nguyen et al.	2018	43	This study presents a literature review of BDA in SCM based on the content analysis method.	Literature review, Research directions
Sanders	2016	42	This paper identifies three distinct differences in today's BDA capability: an unprecedented opportunity for inquiry, change like inquiry and change like experimentation. This has led to an array of application capabilities that is vast, tempting, and even overwhelming.	Decision Making
Mishra et al.	2018	38	This study presents a bibliometric analysis of BD and SCM.	Bibliometric analysis, Network analysis

(continued).

Table B2. Continued.

Authors	Year	Citations	Study	Main Keyword other than BDA and SCM
Lamba and Singh	2017	38	In addition to reviewing past literature, the paper also proposes the application of BD in operations and SCM.	Procurement, logistics
Hofmann	2017	35	This study deals with the potential of BD on the improvement of the various SC processes. This paper aims to elaborate on which characteristic of BD has the greatest potential to mitigate the bullwhip effect.	Bullwhip effect, forecasting
Prasad et al.	2018	28	This study developed a resource dependence model connecting BDA to superior humanitarian outcomes using a case study of twelve humanitarian value streams. This study identified how the various types of data attributes affect humanitarian outcomes in terms of deliverables, lead-times, cost, and propagation.	Resource dependence, Humanitarian outcomes
Dubey et al.	2019b	27	This study investigated the empirical effects of BDPA on social performance (SP) and environmental performance (EP) using variance-based structural equation modeling. This study is based on a sample of 205 Indian manufacturing organizations.	Predictive analytics, Social sustainability
Gunasekaran et al.	2018	24	This study examined the role of DBDA in agile manufacturing practices.	Competitive advantage; performance
Shen and Chan	2017	22	This paper studied a comprehensive review of forecast information sharing for managing SC in the BD era.	Forecasting
Roßmann et al.	2018	20	The study explored the application of BDA in mitigating SC social risk. This research demonstrated how such mitigation could help in achieving environmental, economic, and social sustainability.	Delphi method, Fuzzy logic
Govindan et al.	2018	20	This research presented a variety of opportunities to improve BDA and applications for logistics and SCM, such as those through exploring technology-driven tracking strategies, financial performance relations with data-driven SCs, and implementation issues and SC capability maturity with BD.	Logistics
Lai et al.	2018	18	The paper presents the factors determining the firm's intention to adopt BDA in their daily operations based on the past literature of the BDA and SCM.	Operational performance, logistics
Feng and Shanthikumar	2018	17	This study focuses on two aspects of SCM, namely, demand management and manufacturing in the era of BD.	Demand learning and planning
Mani et al.	2017	16	The study shows that BDA is especially relevant to the domain of SCM as it provides the tools to support decision-making in increasingly global, volatile, and dynamic value networks.	Sustainability, supply chain social sustainability
Seles et al.	2018	16	This work adopted a structured literature review research method. The review showed that the opportunities emerging from the climate crisis tend to improve performance as well as generating new business, while the challenges are related to the lack, or inefficiency, of governmental and regulatory support and high costs.	Global warming, Sustainable operations
Dubey et al.	2019c	16	This study was triggered by the exponential rise in interest in BDPA in the literature on manufacturing and operations management.	Supply chain innovation, Decision-making, Logistics competences, Logistics strategy
Yadegaridehkordi et al.	2018	13	This study aims to identify and rank the significant factors influencing the adoption of BD and in turn to predict the influence of BD adoption on manufacturing companies' performance using a hybrid approach of decision-making trial and evaluation laboratory (DEMATEL) adaptive neuro-fuzzy inference systems (ANFIS).	Manufacturing companies, DEMATEL, ANFIS
Winkelhaus and Grosse	2019	11	The review and the created framework provide a picture of the state of the art of research on Logistics 4.0.	logistics; Industry 4.0; smart; internet of things;
Barbosa et al.	2018	10	This study performed a systematic literature review based on 44 scientific articles. This work aims to manage SCM resources with the usage of BDA.	Supply Chain Intelligence, Resource-based View
Raguseo and Vitari	2018	9	The primary objective of this study was to examine the effects of the business value of BDA solutions on the financial performance of a firm, both directly and indirectly, through customer satisfaction and market performance.	Business value; customer satisfaction; firm performance; resource-based view
Queiroz and Telles	2018	9	This paper recognized the current state of BDA on the different organizations and SCM levels in Brazilian firms. It focused on BDA awareness in the firms.	Decision-making, Logistics strategy.
Shukla and Tiwari	2017	8	This paper proposed a BDA framework enabled by cutting edge technologies to incorporate smallholders in the Roundtable on Sustainable Palm Oil' certification process	Sustainable production, new technologies
Lamba and Singh	2018	8	This study believed that BDA has immense potential to revolutionise existing operations and SCM theories.	Fuzzy-TISM, DEMATEL

(continued).

Table B2. Continued.

Authors	Year	Citations	Study	Main Keyword other than BDA and SCM
Isasi et al.	2015	7	This study presented the bibliometric and systematic analysis of the BD/BA application in the SCM.	Bibliometric, Systematic Analysis
Hofmann and Rutschmann	2018	7	This paper examined how BDA enhances forecasts' accuracy. The developed framework could serve as the first guide for meaningful BDA initiatives in SC.	Forecasting methods
Liu and Yi	2018	6	This article provided theoretical guidance or a decision basis for companies investing in Big Data Information (BDI), meanwhile, it had reference values for SC coordination after investing in BDI.	Investment decision-making
Gravili et al.	2018	6	This paper examined the influence of the Digital Divide (DD) and Digital Alphabetisation on the BD generation process, to gain insight into how BD could become a useful tool in the decision-making process of SCM.	Digital Divide
Raman et al.	2018	6	This study focused on BD, which offers new opportunities, added value, and operational excellence for existing SC practices. This research also gave a new description of the Supply Chain Operations Reference (SCOR) model.	Demand management, Internet of things
Kamble and Gunasekaran	2020	6	The findings of the study reveal that to achieve predictive big data-driven supply chain (BDDSC) performance; the organizations should have an integrated performance measurement system that combines both the performance measures of BDA and BDDSC processes.	Performance measures, predictive analytics
Shukla et al.	2019	5	The paper summarizes the discussions on the use of BDA in the manufacturing and service sectors.	manufacturing and service sectors
Mukherjee and Sinha	2018	4	This study developed an integrative theoretical framework for identifying the sources of judgment bias in product recall decisions. It has also analyzed the user-generated reports on adverse events related to medical devices using a combination of econometric and predictive analytic methods.	Product recalls, judgment bias
Malik et al.	2018	3	This paper reviews healthcare operations and data mining frameworks.	Healthcare operations management, Systematic literature review
Bahri et al.	2019	3	This study outlines the importance of BD on medical stakeholders, patients, physicians, pharmaceutical and medical operators, and healthcare insurers, and also reviews the different challenges that must be taken into account to get the best benefits from BD and its applications.	Healthcare
Yang et al.	2019	3	This paper first builds up an evaluation process model of metropolitan economic and logistics development, based on BDA, the entropy evaluation method, and the maximum deviation method.	city logistics; coordinated development;
Hamister et al.	2018	1	This study presented a case study of an ongoing partnership between the authors and corporate managers at a distributor of heating, ventilating, and air-conditioning products.	Data science, Inventory management
Tao et al.	2018	1	This study proposed a trustworthy scheduling optimization approach for agricultural products SC by using BD.	Optimization, evolutionary algorithm
Galetsis and Katsaliaki	2019	1	The paper shows that BDA is of paramount importance in healthcare aspects such as patient diagnostics, fast epidemic recognition, and improvement of patient management.	Health analytics, bibliometric; sources of data
Mandal	2019	0	This paper explored the impact of BDA management capabilities, namely, BDA planning, BDA investment decision making, BDA coordination, and BDA control on SC resilience dimensions, namely, SC preparedness, SC alertness, and SC agility.	Resource-based view, Business value of IT
Chehbi-Gamoura et al.	2020	0	This research investigated how different activities in SCM have adopted BDA.	SCOR matrix, Nomenclature grid

Appendix C

Table C1. The most cited papers of BDA with consideration of SCM, LM, and IM

Title	Citations	Authors	Publication Year
'Big data analytics in logistics and supply chain management: Certain investigations for research and applications'	260	Wang et al.	2016
'Intelligent Manufacturing in the Context of Industry 4.0: A Review'	245	Zhong et al.	2017a
'Big data and predictive analytics for supply chain and organizational performance'	147	Gunasekaran et al.	2017
'Big Data for supply chain management in the service and manufacturing sectors: Challenges, opportunities, and future perspectives'	128	Zhong et al.	2016a
'Insights from hashtag #supply-chain and Twitter Analytics: Considering Twitter and Twitter data for supply chain practice and research'	122	Chae	2015
'The role of Big Data in explaining disaster resilience in supply chains for sustainability'	113	Papadopoulos et al.	2017a
'The impact of big data on world-class sustainable manufacturing'	108	Dubey et al.	2016
'Data Science, Predictive Analytics, and Big Data in Supply Chain Management: Current State and Future Potential'	97	Schoenherr and Speier-Pero	2015
'Challenges and opportunities of digital information at the intersection of Big Data Analytics and supply chain management'	82	Kache and Seuring	2017
'Big Data Analytics for Physical Internet-based intelligent manufacturing shop floors'	80	Zhong et al.	2017b
'Visualisation of RFID-enabled shop floor logistics Big Data in Cloud Manufacturing'	79	Zhong et al.	2016b
'How the Use of Big Data Analytics Affects Value Creation in Supply Chain Management'	79	Chen et al.	2015
'Machine Learning and Decision Support in Critical Care'	78	Johnson et al.	2016
'Prediction of In-hospital Mortality in Emergency Department Patients With Sepsis: A Local Big Data-Driven, Machine Learning Approach'	77	Taylor et al.	2016
'Managing a Big Data project: The case of Ramco Cements Limited'	75	Dutta and Bose	2015
'An optimization model for green supply chain management by using a big data analytic approach'	75	Zhao et al.	2017
'Big data applications in operations/supply-chain management: A literature review'	75	Addo-Tenkorang and Helo	2016
'Big data reduction framework for value creation in sustainable enterprises'	71	Rehman et al.	2016
'Simulation Optimization: A Review and Exploration in the New Era of Cloud Computing and Big Data'	70	Xu et al.	2015
'Recent Development in Big Data Analytics for Business Operations and Risk Management'	66	Choi et al.	2017
'Big data analytics in supply chain management between 2010 and 2016: Insights to industries'	61	Tiwari et al.	2018
'Trends in transportation and logistics'	58	Speranza M. G.	2018
'Mobile Cloud Computing Model and Big Data Analysis for Healthcare Applications'	57	Tawalbeh et al.	2016
'Management challenges in creating value from business analytics'	56	Vidgen et al.	2017
'A systematic review of supply chain knowledge management research: State of the art and research opportunities'	55	Cerchione and Esposito	2016
'Big data and predictive analytics for supply chain sustainability: A theory-driven research agenda'	53	Hazen et al.	2016
'Mapping the Landscape of Future Research Themes in Supply Chain Management'	52	Wieland et al.	2016
'Big Data Analytics in Operations Management'	51	Choi et al.	2018
'How would big data support societal development and environmental sustainability? Insights and practices'	50	Song et al.	2017
'A multidisciplinary perspective of big data in management research'	45	Sheng et al.	2017
'Smart supply chain management: a review and implications for future research'	45	Wu et al.	2016
'Big data analytics in supply chain management: A state-of-the-art literature review'	43	Nguyen et al.	2018
'How to Use Big Data to Drive Your Supply Chain'	42	Sanders	2016
'Understanding big data analytics capabilities in supply chain management: Unravelling the issues, challenges and implications for practice'	39	Arunachalam et al.	2018
'Big Data and supply chain management: a review and bibliometric analysis'	38	Mishra et al.	2018
'Big data in operations and supply chain management: current trends and future perspectives'	38	Lamba and Singh	2017
'Back in business: operations research in support of big data analytics for operations and supply chain management'	37	Hazen et al.	2018
'A multi-agent based system with big data processing for enhanced supply chain agility'	35	Giannakis and Louis	2016
'Big data and supply chain decisions: the impact of volume, variety and velocity properties on the bullwhip effect'	35	Hofmann	2017
'Big data text analytics: an enabler of knowledge management'	33	Khan and Vorley	2017
'Big data in humanitarian supply chain networks: a resource dependence perspective'	28	Prasad et al.	2018
'A global exploration of Big Data in the supply chain'	24	Richey et al.	2016
'Impact of big data and predictive analytics capability on supply chain sustainability'	23	Jeble et al.	2018
'Can big data and predictive analytics improve social and environmental sustainability?'	22	Dubey et al.	2019b
'Forecast Information Sharing for Managing Supply Chains in the Big Data Era: Recent Development and Future Research'	22	Shen and Chan	2017
'Big data and predictive analytics in humanitarian supply chains: Enabling visibility and coordination in the presence of swift trust'	21	Dubey et al.	2018
'Big data analytics and application for logistics and supply chain management'	20	Govindan et al.	2018
'The future and social impact of Big Data Analytics in Supply Chain Management: Results from a Delphi study'	20	Roßmann et al.	2018

Appendix D

Table D1. Known and Unknown in the Field of BDA-SCM

Known for BDA-SCM	Unknown for BDA-SCM
Demand Forecasting	Supplier Selection
Quality Control	Order Selection
Scheduling	Closed-loop Supply Chain
Maintenance	Reliable Supply Chain through the Internet of Things (IoT)
Logistics	Sustainability Initiatives in SCM
Inventory Control	
Risk Analysis	