Big Data Applications in Supply Chain Management: SCOPUS Based Review

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***Abstract*—For modern industry, supply chain optimization is becoming very important. To stay ahead of the competition, companies must be able to optimize their supply chain. Customers expect fast order fulfilment and delivery, as well as product options, styles and features. Companies that meet these expectations are expected to succeed. Big Data plays an important role in various areas of supply chain management, such as demand forecasting, product development, delivery decisions, sales and customer feedback. The increasing amount of data shared by supply chains in manufacturing and service sectors justifies the use of Big Data in supply chain management. This paper reviews research activities in the area of Big Data in supply chain management. It also examines the applications of Big Data in supply chain management, opportunities, challenges and future trends.**

***Index Terms*—Big data, supply chain management, SCOPUS**

I. Introduction

Big Data is a relatively new trend that companies can exploit. In this article, the focus is specifically on the applications of Big Data in supply chain management. The term 'Big Data' refers to a huge amount of available data that is being generated at a rapid pace from various sources. If we consider the upstream and downstream areas of supply chain management, many operations generate data that can be used. The use of Big Data is not equally present in all functions of supply chain management.

Supply chain management has various aspects that are influenced by operations management, material distribution management, logistics and transportation, purchasing and information technology. Supply chain management is the study of intra- and inter-organizational operations and processes in the supply of products and services to end users. It includes material procurement, purchasing, production facilities, logistics, marketing and other related systems that enable the upstream and downstream flow of materials, services, finances and information [1]. From a logistics perspective, supply chain management includes supply chain structures, such as participating companies along the supply chain, business processes and management, such as planning, control, product development and the flow of products and information [2]. The authors identified three levels of research in supply chain management: functional level phenomena, intra-firm relationships and inter-firm supply chains.

The development of information and Big Data provides opportunities for different organizations to improve supply chain management based on better decision making, which will lead to better performance. In this paper, we review the literature that frames the importance and applications of Big Data in supply chain management. The merging of these two topics is an important area for managers and researchers. It has been recognized that Big Data can improve and change supply chain management practices.

The main objective of the study is to provide a literature review on Big Data in supply chain management. SCOPUS articles on this topic are reviewed. A breakdown of the articles by year of publication, topic and affiliation was performed. In addition, an abstract of each article is provided. In the hope that the literature review will answer these, two questions:

1. What is the potential of Big Data in supply chain management?
2. What are the areas to consider for future research and development that will lead to the integration of Big Data into business processes to improve supply chain management?

II. Big Data

Gandomi and Haider [3] introduced a broad definition of Big Data that takes into account the fundamental concepts associated with it. There are several definitions of Big Data that have evolved rapidly. Diebold [4] examined the origins of Big Data, the concept, the phenomenon and the discipline. He stated that Big Data was present at Silicon Graphics (SGI) as early as the mid-1990s, when John Mashey, the retired chief scientist of SGI, produced an SGI presentation entitled "Big Data and the New Wave of InfraStress" in 1998. Since then, Mashey and the SGI community have made the term 'Big Data' the subject of conferences, workshops and technical seminars. Fig. 1 shows the growth in the number of SCOPUS articles in which the term 'Big Data' appears over the last twenty years. It shows that the term has been widely used since 2011 and the rate of increase has been rapid.

Several authors have addressed the definition and characteristics of Big Data [5-9]. Although several definitions of Big Data have been cited in the literature, researchers have agreed on the characteristics of Big Data: Volume, Variety and Velocity, or the so-called three Vs. Volume refers to the size of data, which is usually expressed in several terabytes and petabytes.

According to Schroeck *et al.* [10], 50 per cent of respondents in an IBM survey consider data of one terabyte or more to be Big Data. The volume of Big Data is a relative term that depends on the time and type of data. According to McAfee *et al.* [11], the amount of data generated daily was 2.5 exabytes in 2012, doubling every 40 months. Data storage

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has moved from analogue to digital as computing power has increased. Variety refers to different sources and different forms of Big Data. Data can be structured, semi-structured or unstructured, public or private, shared or confidential, complete or incomplete, etc. With the increase in data sources, the new concept of the Big Data chain has materialized, which includes multiple data sources, flow variations and multiple decisions [12]. Velocity refers to the speed at which Big Data is generated and processed. Data must be analyzed and processed quickly to provide useful information. Oussous *et al.* [6] reported that Wallmart generates over 2.5 PB of data from customer transactions every hour. Hofman [13] concluded that speed has the highest potential to improve performance compared to the effect of volume and variety. Zhomg *et al.* [14] described two other Vs in the environment of service and production supply chain management, namely verification and value. Verification is a necessary tool to select good data, control quality and resolve compliance issues. Verification focuses on the inherent unreliability of some data sources. The value of Big Data is difficult to measure; it is difficult to assess the impact of Big Data on profits and business processes in the service and manufacturing sectors. Big Data generates value through extraction and transformation to the extent represented by the value attribute. Oracle's definition includes that Big Data is often characterized by "low value density" [3].

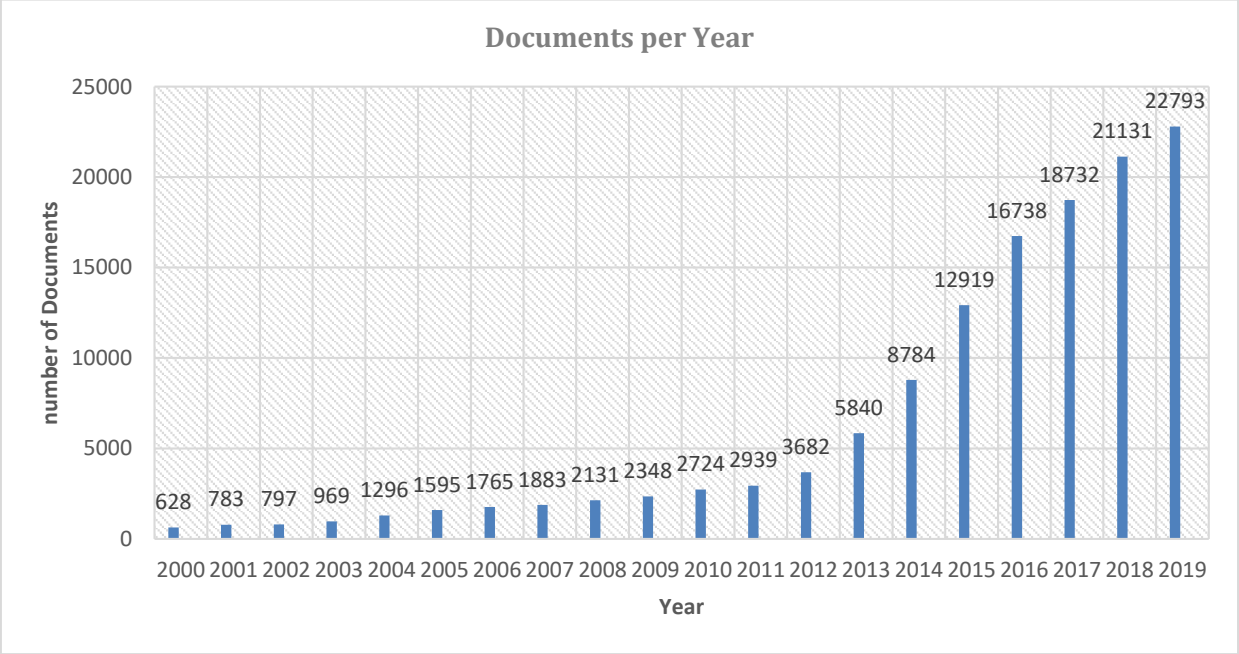

Fig. 1. Number of SCOPUS documents containing the term "Big Data".

Big Data deals with the flow of data, information and knowledge. Several authors [3, 6]; have discussed the process of extracting information and insights from Big Data. Fig. 2 shows the two sub-processes and the five steps involved. The Data Management sub-process includes the steps of capture and recording, extraction, cleaning and annotation, and integration, aggregation and representation. The Analytics sub-process includes modelling, analysis, and interpretation.

Big Data analytics encompasses a wide range of techniques, including text analytics, audio analytics, video analytics, social media analytics and predictive analytics. Text analytics is the extraction of information from textual data; it can be performed using a variety of methods, including information extraction [15], text synthesis [16], question answering [3], and sentiment analysis [17]. Audio analysis is the analysis and extraction of information from audio data, also known as discourse analysis. Call centers in different organizations can use audio analytics, which helps to improve customer service. There are two approaches to speech analytics: continuous speech recognition with a large vocabulary and phonetics-based approach [3]. Video analytics involves monitoring, analyzing and extracting information from video streams. An example of video analytics is the use of data generated by CCTV cameras in various organizations [18]. Social media analytics is the analysis of data from social media channels such as social networks, blogs, microblogs, social news, social bookmarks, media sharing, wikis and review sites [17]. Predictive analytics uses statistical methods to analyze historical and current data to predict future outcomes. Predictive analytics can be used and applied in any domain [17, 19].

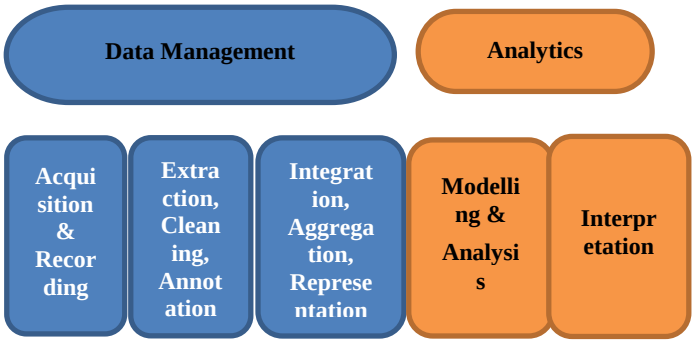

Fig. 2. Stages of extracting information & insights from big data.

Elgendy and Elraga [20] discussed the integration of Big Data analytics in decision-making. They proposed a Big Data analytics and decision-making framework to support decision making in organizations. If the framework that includes the data analytics lifecycle, infrastructure, architecture and tools

needed. It is therefore expected to improve the quality of decision-making.

III. Big Data in Supply Chain Management

Fig. 3 shows the growth in the number of SCOPUS articles containing the term 'Big Data and Supply Chain Management' over the last decade. The number of SCOPUS publications in the area of Big Data in supply chain management has tended to increase. In 2010, the number of publications was 9 and by the end of 2019, it was 159, which clearly indicates that the applications of Big Data in supply chain management are growing.

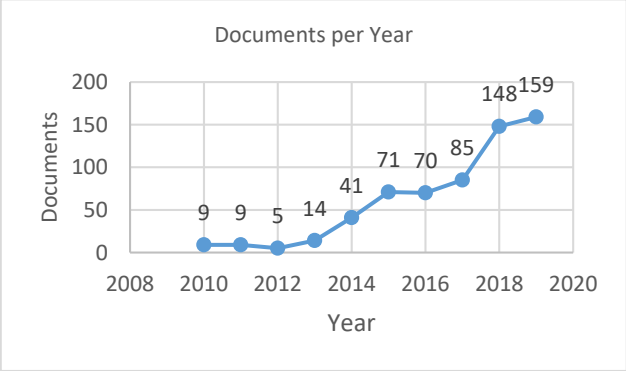

Fig. 3. SCOPUS documents related to applications of big data in supply chain management.

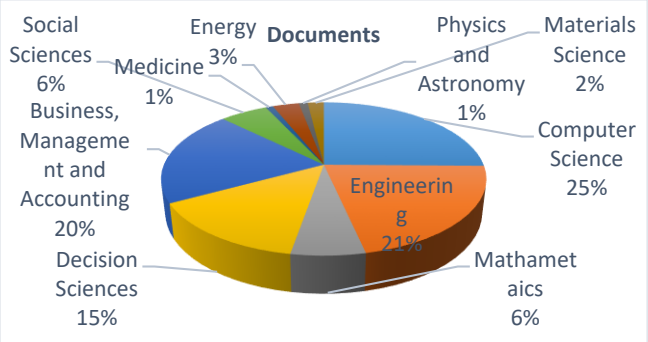

Fig. 4. Subject classification of big data in supply chain management topics as revealed by SCOPUS during the period 2010 – 2019.

Fig. 4 shows the thematic classification of articles published in SCOPUS on big data in supply chain management. Computer science, engineering, business administration, management and accounting, and decision sciences have the highest percentages with 25%, 21%, 20% and 15% respectively. Fig. 5 provides an overview of SCOPUS document types for the period 2010 - 2019. Journal articles, followed by conference papers, are the most numerous with 275 and 225 articles respectively. Fig. 6 shows the number of SCOPUS articles on the topic Big Data in Supply Chain Management with contributions per country of origin. The US tops the list, followed by China, UK, India, Germany, France, Australia, Hong Kong, Italy and Malaysia with 117, 109, 62, 61, 43, 38, 24, 23, 17 and 16 respectively. Table I presents a summary of the twenty most cited articles. Waller and Fawcett's [21] article in the Journal of Business Logistics was the most cited, in which the authors discuss the applications of Big Data in supply chain management and provide examples of research questions from these applications. Wolfert *et al.* [22] in their review article discussed the use of technologies such as Internet of Things (IO), cloud computing, artificial intelligence (AI) and robotics with Big Data in agricultural operations. Hazen et al [23] discussed the problem and suggestions for research and applications in data quality for data science, predictive analytics and Big Data in supply chain management. Wang *et al.* [24] studied various applications of Big Data Business Analytics (BDBA) in logistics and supply chain management (LSCM).

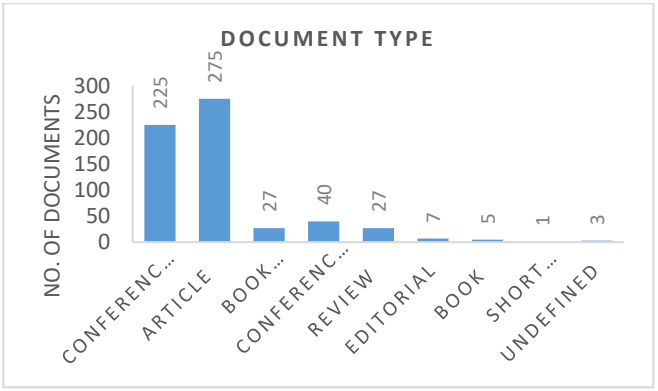

Fig. 5. Types of SCOPUS Documents.

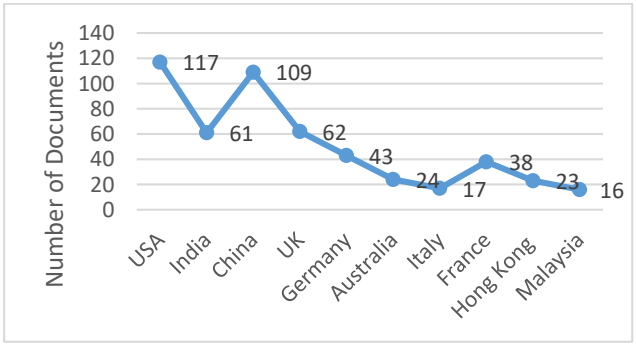

Fig. 6. Share of country origin publishing SCOPUS documents of big data in supply chain management topics.

Gunasekaran *et al.* [25] discussed the role of Big Data and predictive analytics (BDPA) in supply chain performance and organizational performance. Zhong *et al.* [14] discussed the challenges, opportunities and future prospects of Big Data for supply chain management in the service and manufacturing sectors. They covered the applications of Big Data in finance and economics, healthcare, supply chain management and manufacturing. They also discussed Big Data technologies such as data storage, data processing, data visualization, Big Data analytics and decision-making models and algorithms. They identified various future challenges and opportunities such as data acquisition and transmission methods, storage, processing technologies, decision models and data interpretation. Addo-Tenkorang and Helo [26] conducted an extensive literature review of about 100 articles dealing with Big Data in operations and supply chain management. They proposed a framework based on the Internet of Things and value creation. Boone *et al.* [27] provided an overview on improving sales forecasting in supply chain using Big Data. They showed that Big Data could improve overall forecasting. They also discussed the challenges that can arise in Big Data applications. These challenges include the size and unstructured nature of the data, the ever-changing nature of

customer and supply chain experiences, and the non-replicable nature of the data. Tiwari *et al.* [28] provided an overview of the field through studies on the research and application of Big Data analytics in supply chain management between 2010 and 2016. In their review, they discussed the problems, insights and trends of Big Data in supply chain management. They discussed the addition of value dimension to Big Data to provide decision makers with information value that gives them a competitive advantage over their peers. They highlighted various application areas of Big Data in supply chain management such as strategic sourcing, network design, demand planning, procurement, production, inventory management, product design and development, logistics and distribution, agility and sustainability. Applications of Big Data analytics in business include finance, technology, healthcare and manufacturing.

TABLE I: SUMMARY OF THE TOP TWENTY MOST FREQUENTLY CITED ARTICLES

No.	Document title	Authors	Source	Article Type	Problem Addressed	Scopus Citations
1	Data science, predictive analytics and Big Data: a revolution that will transform supply chain design and management.	Waller, M.A., Fawcett, S.E. (2013)	Journal of Business Logistics 34(2), pp. 77-84	Conceptual	Applications of BD in SCM and provide examples of research questions from these applications.	440
2	Big Data in Smart Farming – A review	Wolfert, S., Ge, L., Verdouw, C., Bogaardt, M.-J. (2017)	Agricultural Systems 153, pp. 69-80	Review	Use of technologies such as IO, cloud computing, AI and robotics in enterprise DB.	316
3	Data quality for data science, predictive analytics and Big Data in supply chain management: an introduction to the problem and suggestions for research and applications.	Hazen, B.T., Boone, C.A., Ezell, J.D., Jones-Farmer, L.A. (2014)	International Journal of Production Economics 154, pp. 72-80	Conceptual and analytical	Data quality problem in supply chain management.	314
4	Big Data analytics in logistics and supply chain management: selected studies for research and applications.	Wang, G., Gunasekaran, A., Ngai, E.W.T., Papadopoulos, T. (2016)	International Journal of Production Economics 176, pp. 98-110	Literature review and classifications	Applications of Big Data Business Analytics (BDBA) in logistics and supply chain management (LSCM).	294
5	Big Data and predictive analytics for supply chain and business performance.	Gunasekaran, A., Papadopoulos, T., Dubey, R., Hazen, B., Akter, S. (2017)	Journal of Business Research 70, pp. 308-317	Review and conceptual	The role of Big Data and predictive analytics (BDPA) for supply chain and business performance.	180
6	Big Data for supply chain management in services and manufacturing: challenges, opportunities and future perspectives	Zhong, R.Y., Newman, S.T., Huang, G.Q., Lan, S. (2016)	Computers and Industrial Engineering 101, pp. 572-591.	Review and analytical	Applications of Big Data in services and manufacturing.	162
7	Insights from the #supplychain hashtag and Twitter analytics: the use of Twitter and its data for supply chain practice and research.	Chae, B. (2015)	International Journal of Production Economics 165,5967, pp. 247-259	Analytical	Using social media such as Twitter and Big Data in supply chain management.	151
8	Data science, predictive analytics and Big Data in supply chain management: current status and future potential.	Schoenherr, T., Speier-Pero, C. (2015)	Journal of Business Logistics 36(1), pp. 120-132	Analytical and survey	Use of predictive analytics in supply chain management.	140
9	Massive data analytics for physical, internet-based workplaces and smart manufacturing.	Zhong, R.Y., Xu, C., Chen, C., Huang, G.Q. (2017)	International Journal of Production Research 55(9), pp. 2610-2621	Analytical	Introducing Big Data analytics for Radio Frequency Identification (RFID) logistics data by defining different behaviours of smart manufacturing objects.	120
10	How the use of Big Data analytics impacts value creation in supply chain management.	Chen, D.Q., Preston, D.S., Swink, M. (2015)	Journal of Management Information Systems 32(4), pp. 4-39	Analytical and conceptual	Conceptualises the use of Big Data Analytics as an information processing capability that gives companies a competitive advantage.	109
11	Accounting for companies' water footprint and impact assessment: the case of the water footprint of a sugary soft drink.	Ercin, A.E., Aldaya, M.M., Hoekstra, A.Y. (2011)	Water Resources Management 25(2), pp. 721-741	Analytical	Analysis of the water footprint of beverage ingredients along the supply chain.	106
12	Challenges and opportunities of digital information at the intersection of Big Data analysis and supply chain management.	Kache, F., Seuring, S. (2017)	International Journal of Operations and Production Management 37(1), pp. 10-36	Theoretical	Using the Delphi research technique to better understand the opportunities and challenges of adopting Big Data analytics in SCM.	99
13	Big data analytics in supply chain management between 2010 and 2016: insights for industries.	Tiwari, S., Wee, H.M., Daryanto, Y. (2018)	Computers and Industrial Engineering 115, pp. 319-330.	Analytical and review	Examines the research and application of Big Data analytics in supply chain management between 2010 and 2016.	84

14	Applications of Big Data in operations and supply chain management: a review of the literature.	Addo-Tenkorang, R., Helo, P.T. (2016)	Computers and Industrial Engineering 101, pp. 528-543	Literature Review	Discusses the key issues of Big Data and proposes a framework for value creation in supply chain management.	82
15	Collaboration performance in supply chain - A simulation study.	Ramanathan, U. (2014)	Expert Systems with Applications 41(1), pp. 210-220	Simulation	Using real industry data and simulations to help management make decisions on the number of partners collaborating in the supply chain process.	80
16	Big Data reduction framework for value creation in sustainable enterprises.	Rehman, M.H.U., Chang, V., Batool, A., Wah, T.Y. (2016)	International Journal of Information Management 36(6), pp. 917-928	Conceptual	Introducing a new concept of customer-side Big Data reduction, where initial data reduction tasks are performed to achieve multiple objectives.	79
17	Internet of Things in agriculture, current progress and future challenges.	Tzounis, A., Katsoulas, N., Bartzanas, T., Kittas, C. (2017)	Biosystems Engineering 164, pp. 31-48	Analytical and Review	Research on IoT technologies, their current penetration, potential and challenges in the agricultural sector.	78
18	Click here to become a data scientist: Big Data, predictive analytics and theory development in the era of the Maker Supply Chain movement.	Waller, M.A., Fawcett, S.E. (2013)	Journal of Business Logistics 34(4), pp. 249-252	Theoretical	Develop a model to explain the role of predictive analytics in the theory development process.	78
19	Environmental analysis of the impact of population growth on supply chain performance and economic growth in Indonesia.	Haseeb, M., Zandi, G., Hartani, N.H., Pahi, M.H., Nadeem, S. (2019)	Ekoloji 28(107),e107019, pp. 417-426	Analytical	To study the role of supply chain performance in Indonesia's economic growth.	70
20	Supply chain becomes a demand chain	Christopher, M., Ryals, L.J. (2014)	Journal of Business Logistics	Analytical	Transforming supply chains into demand chains to reduce waste and obsolescence. This is based on the argument that companies will not create demand if they cannot meet it.	65

Nguyen *et al.* [29] reviewed the literature on Big Data analytics in supply chain management. In their study, they discussed the various applications of Big Data analytics in supply chain management, the level of Big Data analytics and models, and Big Data analytics techniques. In their assessments, they covered various functions of supply chain including logistics/transportation, manufacturing, warehousing, and demand management. They also discussed the level of Big Data analysis: descriptive, predictive and prescriptive. The models covered include visualization, regression, clustering, simulation, prediction, semantic analysis, association, classification, optimization, and mixed. Singh *et al.* [30] identified supply chain management problems using Delphi technique and proposed Big Data analysis to solve them. They argued that the use of Big Data analytics would reduce the complexity of supply chain management.

Oncioiu *et al*. [31] studied the impact of Big Data analytics on firms' performance in supply chain management. Specifically, they focused on the case of Romanian supply chain companies; they evaluated their experiences, strategies and capabilities to implement Big Data analytics. In their study, they used a quantitative market research method to identify companies' experiences in applying Big Data analytics in supply chain management, suitable strategies to implement Big Data analytics, required capabilities, tools used, results obtained after using Big Data analytics and companies' future intention to implement Big Data analytics. The author suggested several areas for further research, including (1) the impact of Big Data analytics on supply chain management using various information analysis techniques (2) the opportunities and benefits of using Big Data analytics in optimizing supply chain management (3) the impact of Big Data on economic value in companies (4) Big Data in large and/or small and medium-sized companies in the public and private sectors, and (5) the effectiveness of information use after using Big Data in a particular industry in decision making.

IV. Concluding Remarks

It has become clear that companies throughout the supply chain are faced with a huge amount of variable data and need to process it. They need to use data analytics techniques to leverage the processed data. From a business perspective, analyzing data and using the information extracted during the process to support decision-making is called business intelligence. Once information is converted into intelligence by combining analytics and Big Data, business intelligence can be achieved, which leads to better performance.

Businesses depend on supply chain optimization to gain competitive advantage. Companies need to collaborate with upstream and downstream suppliers and be able to optimize their supply chain. Customers expect fast order processing and delivery, as well as product options, styles and features. Companies that meet these expectations are expected to succeed. Sharing customer demand data and predictive analytics is an important step. Big Data plays an important role in various areas of supply chain management, such as demand forecasting, product development, delivery decisions, sales and customer feedback.

Effective use of Big Data can help improve supply chain management. A good understanding of market trends and customer needs would enable a responsive supply chain. The use of Big Data and Internet of Things in all supply chain activities would lead to a reliable supply chain. Big data

analytics can be used throughout the end-to-end supply chain.

Effective use of Big Data sources can improve the supply chain process. The applications of Big Data analytics can be highlighted in various supply chains such as healthcare, finance, technology, energy, manufacturing, engineering, material science and hospitality.

The literature review answered the first question: what is the potential of Big Data in supply chain management? In the areas of logistics and distribution, transportation, production planning and control, supply chain networks, demand planning, product design and development, procurement, manufacturing and inventory management.

What are the areas to consider for future research and development that will lead to the integration of Big Data into business processes to improve supply chain management? The literature review suggests some future directions in the development of Big Data research in the supply chain management environment, which could include:

1. Investigating the impact of Big Data analysis on supply chain management using different data analysis techniques.

2. Combine different data analysis techniques to develop advanced models for decision support systems.

3. Explore the opportunities and benefits of implementing Big Data analytics in supply chain management optimization.

4. Examine the three levels of analytics: prescriptive, descriptive and predictive analytics.

5. Examine the implementation of Big Data in large enterprises or VSEs: opportunities, challenges, benefits and disadvantages.

6. The impact of Big Data implementation on economic value in the business environment.

7. To study the implementation of Big Data in different industries and the effectiveness of using the information in decision-making.

8. To study the business models driven by Big-Data in the supply chain.

Conflict of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

As the sole author, I take full responsibility for the content of the manuscript and have approved the final version for publication.

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