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# Big Data for Supply Chain Management in Industry 4.0 Context : A Comprehensive Survey

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**ABSTRACT:** *The world now knows a great evolution and explosion of new technologies in many domains that change our lives everyday. Obviously, This lead also to the emergence of new generation of industries commonly known as industry 4.0. Big Data is one of those great technologies, which has considered as the backbone of this type of industry. Hence, that will arise new challenges for companies, and lead them to think differently in the way they design, manage and automate their supply chains processes in order to compete better in the global market and improve their business. The competition within the market space has evolved from "firm versus firm" towards "supply chain versus supply chain". During supply chain operations a great amounts of data are generating. Consequently Big Data Analytics capabilities could be considered the main key to improve data-driven decision making. Additionally, it enable to develop innovative ways that improve business efficiency and effectiveness from this vast amounts of data. Moreover, it provide a 360-degree view of company operations. This review paper is interested in showing the importance of Big Data and Big Data Analytics in the Smart Supply Chain Management. More precisely, how they contribute in making SCM entities ( Procurement, Manufacturing, Logistic/Transportation, Warehousing and Demand management) smarter to be suitable in industry 4.0 context.*

**KEYWORDS:** *Supply Chain Management, Big Data, Big Data Analytics, Industry 4.0, Supply Chain Analytics.*

## 1 Introduction

The evolution and appearance of different technologies in various domains around the world leads to the emergence of a new generation of industry or future industry. Commonly known as **Industry 4.0** and represents the fourth revolution that has occurred in the digitization of manufacturing and Supply Chain (SC). Furthermore, as Industry 4.0 unfolds, computers and machines are connected and communicate with each another to ultimately make decisions without even human involvement. A combination of cyber-physical systems, Internet of Things (IoT) and Internet of Systems (IoS) makes Industry 4.0 possible and the smart factory a reality (Marr 2018). As a result of the support of smart machines that keep getting smarter as they get access to more data, enterprises factories will become more efficient and productive and less wasteful. Thus, these enterprises if they want compete better in the global market and improve their business, they have also use and adopt all these new technologies to manage their logistics and supply chains. Indeed, they have to master their Big Data, use autonomous equipment and vehicles which provide autonomous cranes and trucks to streamline

logistic operations, use also robotics which are leveraging autonomous robots that help to picking products at a warehouse and can quickly and safely support manufacturers, 3D printing which opened up a lot of possibilities for production and IoT which is a key component of industry 4.0. That is probably why some scholars argue that competition within the market space, has evolved from "firm versus firm" towards "supply chain versus supply chain". Obviously, BD has a great impact on supply chain management (SCM) of companies due to the continuous development of information technology which is growing exponentially. As well known, companies generate a great amount of data every moment which comes from different sources namely, Customers data, Suppliers data, Enterprise Resource Planing (ERP), Radio Frequency Identification (RFID), Sensors, IoT, mobile devices, online social networks, etc.

The efforts to strengthen the supply chain analytics capabilities become an important focus for all supply chains, it is a fact that big data can support the end-to-end visibility in the supply chain and create more agile and sustainable logistics/supply chain strategies (Tiwari, Wee & Daryanto 2018). Therefore

During their supply chains operations, organizations generate a great variety of data. These various data type could be collected from heterogeneous or homogeneous sources in structured, semi-structured, and unstructured formats. By adopting strategies of Big Data Analytics (BDA) to analyze, store and manage their data, many companies have achieved sustainable competitive advantages and enhanced their productivity in the global market (Wamba, Gunasekaran, Akter, fan Ren, Dubey & Childe 2017). In this review paper we have interested in showing the importance of BD, BDA and their applications in Smart Supply Chain Management (SSCM) development of information technology which is growing exponentially, and summarizing the current trends and applications of BD in every SC function. More precisely how they contribute in making SCM functions (Procurement, Manufacturing, Logistic/Transportation, Warehousing and Demand management) smarter to be suitable in industry 4.0 context.

This review paper is structured as follows: the first section consist of an introduction. In the second section, we discussed definitions and concepts of BD and BDA levels. While in the third section we highlighted the importance of BDA in SCM, well known data sources in SCM and applications of BDA in each entity of SC, and models and techniques of BD in SCM. In the fourth section we mentioned Challenges and issues in adopting BDA for SC. Whereas in the last section we concluded our paper and mentioned some future works.

## 2 Big Data and Big Data Analytics

BD has the potential to revolutionize the art of management and it provides innovative tools and techniques in capturing and generating business value for enterprises and thus enhancing the Supply Chain performances.

### 2.1 Big Data Definitions and Concepts

The life of an enterprise architect is becoming busy and difficult. Before the era of big data, the enterprise manager only had to worry about the data and systems within their own data center. However, over the past decade there were revolutionary changes to the way information is used by businesses, and how data management platforms support the information available from modern data sources (Ema 2017). This explosion of data was leading (Fosso Wamba Samuel 2015) in their paper to ask this question, Should we develop internal data centers at the firm level or move toward a cloud-based architecture for data storage?. The increasing of data amount that an enterprises generate introduces a host

of complexities, and make challenges for their managers focused on storage, security, privacy, and control. To address all these complexities which are beyond the ability of typical database software tools SGBD, many new diverse platforms have been developed to support these big data initiatives over the last decade. The most famous platforms are Hadoop, NoSQL platforms which include Cassandra and MongoDB, Enterprise Data Warehouse, Data Marts and operational support platforms such as enterprise applications like ERP and other SCM systems.

Many academics and professionals were trying to make a definition to big data. In this paper, we give some of them, and we refer the reader to (Fosso Wamba, Akter, Edwards, Chopin & Gnanzou 2015) for further definitions.

**(IBM, 2017)** Big data is a term applied to data sets whose size or type is beyond the ability of traditional relational databases to capture, manage and process the data with low latency. Big data has one or more of the following characteristics: high volume, high velocity or high variety. Artificial intelligence (AI), mobile, social and the Internet of Things (IoT) are driving data complexity through new forms and sources of data. For example, big data comes from sensors, devices, video/audio, networks, log files, transactional applications, web, and social media, much of it generated in real time and at a very large scale.

**(Rouse, 2011)** Big Data: description of the voluminous amount of unstructured and semi-structured data a company creates or data that would take too much time and cost too much money to load into a relational database for analysis.

BD has been characterized in general by 5Vs: volume, variety, velocity, veracity, and value (details and descriptions of these concepts can be found in (Benabdellah, Benghabrit, Bouhaddou & Zemmouri 2016) and (Fosso Wamba et al. 2015)):

### 2.2 Big Data Analytics

In order to stay more competitive in the global market, companies have to master their BD. BDA which is an emerging technology as a holistic approach permits these companies to manage, process and analyze 5Vs data-related dimensions. Accordingly, to create relevant ideas for delivering sustained value, measure performance and establish competitive advantages (Wamba et al. 2017). In addition, improve data-driven decision making and develop innovative ways that enable improving business efficiency and effectiveness from those vast amounts of data. Researchers and professionals consider BDA as a "fourth paradigm of science", a "new paradigm of knowledge assets" or "the next frontier for innovation, competition, and productivity" (Manyika, Chui, Brown & Bughin 2011). The interest of BDA is to shake up

classical analysis by providing agility in the way of apprehending and solving problems. Indeed, by processing heterogeneous data simultaneously and real-time processing, and analytics. That can be done for example using machine learning and deep learning technologies. In one hand it is worth noting that it is possible to apply Business Intelligence (BI) methods, including data visualization, and advanced analytical methods such as data mining. In the other hand there is a set of methods and techniques specific to Big Data, if only because, BI and data mining tools cannot handle unstructured data.

Depending on the depth of analysis and data types, data analytics techniques are classified into three levels: **Descriptive analytics** provides information about what has been achieved and therefore helps to understand what has happened. **Predictive analytics** provides models to predict what might will happen. It mostly relies on Data Mining, machine learning and deep learning techniques which provides statistical models. A common technique is regression analysis, which predicts the values of several related variables. **Prescriptive analytics** helps to choose the best solution among several possible solutions to guide what is going to happen in the future.

### 3 Big Data Analytics in Supply Chain Management

In this section, we will try to answer three main questions about the use of BD in SCM. These questions are: (i) In what areas of SC, BD is being generated? (ii) In what areas of SC, BDA is being applied? (iii) and what models and techniques of BDA are applying in SCM? Supply Chain or Extended enterprises can be defined as a combination of different and independent services such as Marketing, Procurement, Warehouse Management and Transportation. All these services are interlinked and connected to each others, directly or indirectly, by sharing information, material, financial flow (Nguyen, Zhou, Spiegler, Ieromonachou & Lin 2018). SCM information systems is responsible for creating and maintaining the link of these organizations. More precisely between producers and suppliers as well as between their partners, in order to improve their businesses, from procurement of raw materials to ultimate end user delivery of the final product. Within the era of Industry 4.0, the enterprises have got access to a huge variety of advanced technologies such as sensors, IoT, mobile devices, online social networks, etc. In addition they adopt a variety of Information and Communication Technologies for Supply Chain Management (e.g. RFID, Enterprise Resource Planning (ERP), IoT, etc) to collect, manage and store their data. thus, the Supply Chains become more and more complex. This Complexity is associated with the het-

erogeneous material and information flows between supply chain partners. Traditionally, these flows are organized sequentially from supplier to customer. Today, information flows do not follow this linear trajectory. Information flows rather now look like a simultaneous and real-time exchange or even shared, especially through electronic exchanges between all supply chain partners ((Benabdellah et al. 2016)), or through collaborative platforms (Gnimpieba, Nait-Sidi-Moh, Durand & Fortin 2015). Some key characteristics of this complexity are: Number of components, Diversity, Interdependency, Dynamicity, Uncertainty (Benabdellah et al. 2016).

#### 3.1 Big Data Sources in SCM

With the adoption of advanced technologies in SC, the velocity of generating a great variety of data become critical (Li & Liu 2019). The BD could come from different SCM systems, such as:

**Social Media** the embedding of social media in the SC processes can help to gather information from a broad base of different sources. In this case BDA tools can be used to discover new trends or for better-informed decision-making, in order to enhance communication with customers, generate demand, reduce operating costs, mitigate risk, increase productivity, and enhance marketplace intelligence. For instance (Chae & Bongsug 2015) in their study, they developed an analytical framework (Twitter Analytics) for analyzing supply chain tweets, highlighting the current use of Twitter in SC contexts, and further developing insights into the potential role of Twitter for SC practice and research. The main role of their proposed framework is extracting intelligence from 22,399 SC tweets. They found that some SC tweets can be used by different groups of SC professionals and organizations (e.g., news services, IT companies, logistic providers, manufacturers) for information sharing, hiring professionals, and communicating with stakeholders etc. Some others carry strong sentiments about companies' delivery services, sales performance, and environmental standards, and risk and disruption in SCs.

**Radio Frequency Identification (RFID)** which is a form of extremely low-power data communication between a scanner and tags (David & Chadwick 2015). When an item goes through the RFID scanners, information is read from the tag, which could include any amount of information, such as Order ID number, Product bin location, Order status, Serial numbers for individual product components, Location logs. Also, it could updates and transfers information through any RFID receiver, when in range it can be joined with other software to update databases, send information online, or served for data processing (David &

Chadwick 2015). Hence RFID technology can lead to completely autonomous warehouses and distribution centers. In addition in cloud manufacturing systems, this technology is deployed to create an intelligent production environment, where enormous manufacturing data are captured and collected instantly (Zhong, Newman, Huang & Lan 2016). Deployment of RFID tags and readers on logistic objects can convert them from 'passive smart logistics object' to 'active smart logistics object' (Zhong et al. 2016). When these physical objects start communicating via wireless communication, an enormous volume of data are generated in real-time making it difficult to be handled (Arunachalam, Kumar & Kawalek 2018).

**Electronic Data Interchange (EDI)** has improved communication, coordination and collaboration across supply chain processes. Nevertheless, EDI generate a volume of data through data exchange from the involved actors in the supply chain network (Arunachalam et al. 2018), for example, purchase orders, shipment authorizations, shipment acknowledgements, advanced shipment notices, or invoices, etc. SCM EDI transactions must adhere to standardized document formats that are outlined in international standards. The decision about which standard to adopt is determined by factors of global business, industry, or by mutual agreement with a trading partner. There are four main technical standards : UN/EDIFACT, ANSI X12, TRADACOMS, ODETTE.

**Enterprises Resource Planing (ERP)** Is the popular Information Technology (IT), which often serves as a centralized data repository or data IT infrastructure. ERP enable to manage all company's operational processes by integrating several management functions: order management solution, inventory management solution, payroll and accounting management solution, e-commerce management solution, BtoB or BtoC business management solution, in one system. In other words, the ERP represents the "backbone" of a company. Among many benefits, ERP has become a key enabler of data management for supply chain through enterprise-level data acquisition and data access by decision makers (Chae & Olson 2013). Famous known ERP are SAP (mondial leader), Oracle/Peoplesoft, Microsoft, etc).

**Customer Relationship Management (CRM)** refers to information technology or software that manages relationship between business and customers. CRM enables analyzing customer information based on customer data collected (preferences, buying patterns, requested products, etc). It is also applied to the process of managing suppliers, vendors, and other stakeholders, through a buying life-cycle (Özlen & Hadžiahmetović 2013).

**Warehouse management (WMS)**( see warehouse management part in section 3.2 for more details ).

**Cyber Physical System (CPS)** are systems of collaborating computational entities that are in intensive connection with the surrounding physical world and its on-going processes. CPS provide and use, at the same time, data-accessing and data-processing services available on the internet. However advanced concept of CPS today can be considered as the main factor contributing to the development of Industry 4.0. In addition advanced manufacturing concept is investigating from CPS for developing new business models. Thus, By integrating Industry 4.0 and CPS smart devices are able to access and analyse abundant data of themselves as well as other items and thereby automatically react to current health condition. CPS could also be implemented in supply chain management to utilize more efficacy vehicles called shared autonomous vehicles. Furthermore CPS process is called Robotic Process Automation, which could reduce manual work and provide more efficient resource utilization in various areas (Gruzauskas & Navickas 2018). CPS also, enable full transparency of SC's material flows, by collecting and using of large amounts of data trough SC process, and by analyzing and interpreting these data. For example CPS technologies allow tracking products, ensuring security for all chain's elements, accessing to data communication common platform, facilitating the knowledge about demand, stock and sales, sensorial tools for the prediction of eventual anomalies during production, among other factors (Frazzon, Silva & Hurtado 2015).

These complex systems are the primary data sources for the occurrence of data deluge in supply chains. The supply chain data generation was further revolutionised with the advent of IoT technology facilitating real-time sensing and transfer of events data (Arunachalam et al. 2018). In order to use these generated data and preparing them for further processing, by structuring them in a standard formats to obtain integrated data. Online Analytical Processing (OLAP), data warehouses and cloud computing, are examples of IT resources for transforming data to analytical data. Thus, improve supply chain planning and performance management and give decision makers effective operational reporting and dashboards. The process of integrating data often reveals various data quality issues such as inaccuracy and redundancy.

### 3.2 Big Data Analytics Levels in SCM

BDA is considered the main key that enable companies as well as SCs to be adapted in the current fast-paced and ever-changing market environment. Many

researchers reported that BDA in SCM has multiple advantages such as reduced operational costs, improved SC agility, and increased customer satisfaction, etc (Nguyen et al. 2018). In addition, BDA will arise many challenges for data scientists and companies. (Nguyen et al. 2018) in their review paper have designed a global graphical classification framework that englobe SCM functions with the BDA levels and models (Fig. 1). The first layer of this figure shows the main SCM functions namely, Procurement, Manufacturing, Logistic/Transportation, Warehousing and Demand management. The second layer illustrates BDA levels and the last layer mentions some BDA models well-known in the literature.

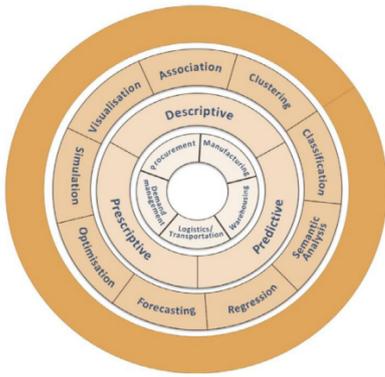


Figure 1 – Classification Framework (Nguyen et al. 2018)

**Procurement** involves the longer term planning of how a firm sets up their purchasing function (Alliance 2009). BDA dedicated in this area, to adress three major issues, which are Supplier Selection, Sourcing Cost Improvement and Sourcing Risk Analysis (Nguyen et al. 2018). To handle Supply Chain Coordination (SCC) especially production procurement coordination, supply chain stakeholders have collectively posed a number of tactical and strategic decisions to achieve mutually defined and shared goals. One of these decisions is Supplier Selection Problem which is considered as one of the main SCC problems by professionals (Igoulalene, Benyoucef & Tiwari 2015). (Shanin 2018) argued that predictive analytics level more specifically, machine learning with intelligent algorithms will challenge supplier relationship management strategies. Furthermore, he also argued that the application of BD models on this issue still in its early stage. However, to enhance their businesses companies in procurement area have to master, accurate and manage suppliers data, and compile the actions and information over a long period of time for present and future use. Procurement professionals have to be in a position of carrying out intelligent and predictive supplier selection, by improving transparency in procurement activities and create more opportunities for relationships in a long-term and find out which sup-

pliers matches their needs and demands. The same case for sourcing cost improvement and sourcing risk analysis, where companies use predictive analytics to reduce sourcing cost and make sourcing process intelligent. For example relying on large sets of historical purchase orders and supplier delivery data, can reveal hidden facts and potential problems with internal sourcing processes and supplier delivery performance (Chae & Olson 2013). Within the increasing of uncertainty in economic, organizations are aware to monitor and manage markets conditions including budgets, profit objectives, market pricing, technology insights and frauds, etc. Thus, companies have to improve their supply chain strategies, by creating what we call supply market intelligence (SMI) (Handfield 2010).

**Logistic/transportation:** in this area BDA aims to develop intelligent transportation systems (ITS) by relying on four fundamental applications among SC: routing optimization, real-time traffic operation monitoring, proactive safety management, logistic planning (Nguyen et al. 2018). (Talari 2018) revealed that BD application will change the world of logistic and transportation due to management of massive flow of goods, and real-time traffic flow information, that create at the same time vast data sets (ex. millions of shipments every day, origin and destination, size, weight, content, and location using GPS or OpenStreetMap data) are all tracked across global delivery networks. Hence delivery processes in logistics have become complex due to travel conditions or traffic information, such as increasing fuel prices, driver shortages, weather conditions, and government regulations and laws. Furthermore, the use of BDA can help to enhance the whole transportation processes involved among SC operations. For example with the help of Big Data technologies, the entire transportation process could be real-time end-to-end tracked (Joshi 2019). (Borgi, Zoghلامي, Abed & Naceur 2017) in their review article "Big Data for Operational Efficiency of Transport and Logistics", argued that taking advantages of capabilities of big data technologies to optimize the utilization of resources and reduce operational costs, can be an important advantage for any logistic providers. In this work, five major issues in logistic and transportation that BDA could adress, were mentioned : Last-mile Delivery, Route Optimisation, Crowdsourcing and Social Transportation, Smart Logistics, and Anticipatory Logistics. For last-mile delivery which is known to be the most complicated and the most expensive part of the delivery process, BDA tools can optimise the matching between demand and available resources, transform the delivery network into a self-organizing infrastructure and help tracking and monitoring automatically freight vehicles and chipment items in real-time. Yamato is one of last-mile delivery company, and is considered

as the largest Japanese door-to-door delivery service (Steger 2017). Whereas in route optimization field, BD descriptive and predictive capabilities and meta-heuristic methods like genetic algorithms help companies to perform optimization tasks. Among these tasks, there are resources planning, optimal path by relying on traffic data or traffic flow, predict and detect traffic congestion on roads and improve punctuality, etc. Crowdsourcing approaches use BD and social transportation to design efficient transportation systems based on the real-time data collection and data updated such as GPS, smart devices, social medias, social behavior, travel behavior, chosen trajectories, cultures and organizations data. Analyzing and managing all these data provide a live description of the traffic situation, and help to build a world of connected people, vehicles, infrastructures and services and produce ITSs (Borgi et al. 2017). The combination of Big Data capabilities and IoT technologies lead to implementing of fully autonomous decision process or self-driving and intelligent vehicles in the transport and logistic field. All these innovative technologies also lead to Smart Logistic. For example, based on sales big data, it is possible to determine which goods and with which quantities are kept in stock in warehouse centers. In the same way Amazon company applied what is called "Antizipatory Shipping" aiming to optimize the delivery time by relying on various sources such as the purchase and search history, notepads or wish lists and the time the mouse pointer stays on certain offers. consequently therefore, that help Amazon company to deliver goods to a delivery warehouse that customers in this region have not yet ordered (Berthold 2019).

**Marketing Intelligence and E-commerce** is generally a subset of economic intelligence that allows companies to develop decision support systems based on big data collected from various systems as discussed above. Analyze these data will help them to master information and derive insights about their customers and markets to better adapt to the environment in which they are located. This allow also to quickly anticipate, adapt, and react to changing business conditions. In this part of SCM, companies are looking to enhance their businesses using predictive analytics. However, that will improve their demand management in terms of shaping demand to be aligned with production and logistics capacity, capturing demand changes in real-time, and sensing demand behaviors to increase the agility and accuracy of demand forecasting (Nguyen et al. 2018). Demand forecasting is one of the critical aspect of SCM, for this reason to address this challenge, companies use predictive analytics or real-time analytics capabilities on customers data (i.e. social media ,sales , customer reviews, behavioral data, etc) in order to improve customer satisfaction, develop innovative products.

Thus, BDA models can help e-commerce supply chain to identify, predict and manage demand chain (Arunachalam et al. 2018). Analytics capabilities especially perspective and predictive analytics can help to enhance demand planning which is a critical function area by gathering customer requirements, collecting information on available resources, and balancing requirement and resources to predict market trends of products and services. More precisely developing supply plans to match market demands (Chae & Olson 2013). Furthermore, growth of e-commerce has brought a lot of new opportunities and challenges to the traditional business models by enabling buyers and sellers to be much closer and connected together on dedicated market platforms (i.e. Amazon, eBay, etc). Indeed organizations today have started working via websites and they are selling or buying via the internet. Thus, e-commerce business is completely impacts SCM, because the development of new e-commerce sites and platforms increases rapidly, but customers prefer that have proper SCM to deliver the products on time and for cheap prices.

**Smart Manufacturing** has always been a backbone of the global economy (Touzout & Benyoucef 2019). Within the evolution of technologies world become more and more digitalised. So to aligned with this great evolution, several companies have transformed their manufacturing systems. To do so they should integrate major management disciplines such as risk management, change management, knowledge management, and project and programme management within their production processes (Kumar, Graham, Hennelly & Srai 2016). In this work the authors proposed an integrated framework, which summarizes the key aspects that help to enhance links between smart city endowed with new manufacturing technologies and logistics with supply chain network design. In addition, it is agreed that in order to seize the smart cities opportunities, firmes should explore their synergies with IoT and Big Data capabilities. In fact, the new manufacturing concepts ( 3D printer, Automation, etc) show us how a smart city production system can change future supply chain design. BDA capabilities in this field of SCM can improve visibility, responsiveness, and performance of material management, and provide a 360-degree view of manufacturing operations (Arunachalam et al. 2018). In addition, all efficient and innovative technologies such as cloud computing, cloud storage, and IoT are creating golden oppotunities for manufacturers who can now use massive data volumes in unexpected new ways and turn it into actionable analytics. This enables to improve business, reassure product quality, increase productivity, and detect anomalies, etc. More precisely, using predictive anlytics enables to monitor manufacturing operations and to predict when a machine or

tool will breakdown, before it starts making up defective products. As well as, using prescriptive analytics to make machines under a total control (White 2015). Furthermore cloud manufacturing is a new paradigm that transform traditional manufacturing resources into smart manufacturing objects (SMOs). These objects can sense, connect, react, interact, and cooperate automatically in order to be able to provide safe and reliable, high quality, sustainable, and on-demand services for the entire manufacturing lifecycle. To do so a large number of sensors are deployed to create an intelligent production environment, where enormous manufacturing data are captured and collected instantly, such as RFID, barcode, QR code, and wireless manufacturing devices, etc (Zhong, Lan, Xu, Dai & Huang 2015).

**Warehousing Management (WM)** is a key part of the supply chain management, that aims to control the movement and storage of material flows within a warehouse. WM treats many transactions associated to these flows including shipping, receiving, putaway and picking, and mainly monitors the progress of products through the warehouse by involving physical warehouse infrastructure, tracking systems, and communication between product stations. BDA in WM focuses on three main operations namely storage assignment, inventory control and order-picking problems (Nguyen et al. 2018). For instance "Wal-Mart store" relies up on modern data management to gain competitive advantage in supply chain and inventory management, making it one of the most profitable business organizations in the 20th Century. It has invested in one of the largest private data management system in the world (Chae & Olson 2013). In addition as we have already discussed about how logistics plays a key role in the supply chain, in this part we are interesting in how it helps enterprises to manage, maintain and optimize their inventory. Thus Warehouse Management System (WMS) is one of the IT logistics systems that help enterprises to store, manage and analyse their data within a warehouse efficiently (i.e. Master data : supplier, items and customer data; Transaction data : receiving, chipping, inventory tracking, cycle counts, inventory adjustments, and value added services data; Business data : customer requirements, consumer behavior, etc). WMS provides the logistics channel visibility across all parties involved in the SCM operations. Accordingly data analytics including predictive analytics, offer a new way to look at all that data for more visibility results in the right actions, at the right time, and efficient business forecasting (Andiyappillai 2019).

The figure 2 below illustrates the main steps to go through, from generating various data amount in every function of SC, and analyzing these data by using BDA levels in order to get insights from them.

Those insights will help companies to better governance of their business and make better decisions.

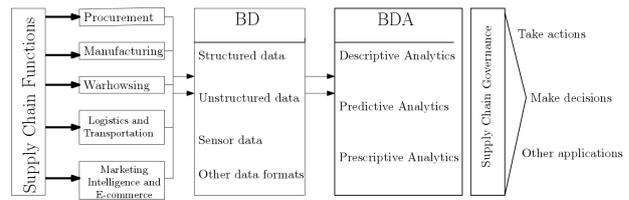


Figure 2 – General Framework of BD and BDA in SCM

### 3.3 SC Analytics and BDA Models and Techniques

Based on literature review we have summarized some BDA applications in CSM by mentioning the most used models and techniques in this field (table 1).

### 4 Challenges and issues in Adopting Big Data Analytics for Supply Chain

With the evolution and changes of BD techs and models and its increasing adoption in SCM field, in order to enhance SCM performances. Companies faces many challenges and issues which can be categorize into two categories such as Organizational and Technical Challenges in each above SC entity :

**BD complexity :** Among SC, complex cross-functional data for interlinked entities being generated, collected and stored should be streamlined. On one hand that will rise difficulties related to access to real time data due to lack of necessary infrastructures to do this operation, because of the incompleteness, the inconsistency and the heterogeneity of these BD. On other hand will also rise another issue related to time-consuming in making the analytics process due to the huge volume of BD generated. When it comes to regional or global Supply Chain Networks, companies might face difficulties in sharing data across its different sources due to various Privacy and Security laws, because lack of shared data in such cases can affect the accuracy of the insights that BDA might generate.

**Lack of skills:** The complexity of Big Data generated from SC operations requires a combination of good domain knowledge analytics skills and the ability to interpret the usability of data which are difficult to find.

**maturity of models :** Organisations in BD models conceptualisations have not yet reach the significant maturity. There are organisations that still in initiation stages. They are aware of BDA and considering it for leveraging, but have not implemented it, are presumably Data Poor and Information Poor, in this case the level of BDA capabilities

**Table 1** – SC analytics and BDA models and techniques

SC entities	Analytic categories in SCM	Models and Techniques	SCM performance
<b>Procurement</b>	<ul style="list-style-type: none"> <li>-Enabling more supplier networks by focusing on knowledge collaboration and supplier selection</li> <li>-E-procurement</li> <li>-Sourcing cost and sourcing risk management</li> <li>-Capture performance requirements for procurement contracts</li> </ul>	<ul style="list-style-type: none"> <li>-Data mining and Machine learning: time series analysis, association rule mining, classification, clustering and Regression and deep learning, etc.</li> <li>-In-memory analytics: in-memory OLAP, in-memory ROLAP, in-memory spreadsheet, etc.</li> </ul>	<ul style="list-style-type: none"> <li>-Sustainability.</li> <li>-Agility.</li> <li>-Collaborative.</li> <li>-data-driven decision making.</li> <li>-Efficient linkage.</li> <li>-Visibility.</li> <li>-Automation and digitization.</li> </ul>
<b>Manufacturing and Planification</b>	<ul style="list-style-type: none"> <li>-Risk evaluation and resilience planning.</li> <li>-Monitoring the performance and improving planning and management functions.</li> <li>-Quality management</li> <li>-Maintenance and diagnosis</li> <li>-Minimizing bottlenecks by developing forecasting techniques</li> </ul>	<ul style="list-style-type: none"> <li>-Real-time analytics: Kafka, Apache, KSQL, SAP HANA, etc.</li> </ul>	<ul style="list-style-type: none"> <li>- Responsiveness.</li> <li>- Flexibility and adaptability.</li> <li>- Serviceability.</li> <li>- Collaboration and Coordination among the partners.</li> </ul>
<b>Warehousing</b>	<ul style="list-style-type: none"> <li>-Managing and optimizing inventories based on user demographics</li> <li>-Storage assignment and order picking</li> <li>-Inventory control</li> </ul>	<ul style="list-style-type: none"> <li>-Natural language processing: Web mining, text mining, sentiment analysis and feature selection.</li> <li>-Spatial regression modeling</li> <li>-Business Intelligence.</li> <li>-Cloud computing.</li> <li>-Crowdsourcing.</li> <li>-Crowdcomputing.</li> </ul>	<ul style="list-style-type: none"> <li>- Transparency in supply chain operations.</li> <li>Connectivity.</li> <li>-Availability of timely, accurate, precise and relevant information.</li> </ul>
<b>Logistics/ Transportation</b>	<ul style="list-style-type: none"> <li>-Routing optimization</li> <li>-Real-time traffic operation monitoring</li> <li>-Proactive safety management</li> <li>-Intelligent transportation system</li> <li>-Logistics planning and in-transit inventory management</li> </ul>	<ul style="list-style-type: none"> <li>-Exact and meta-heuristic optimization methods : Mathematical and dynamic programming.</li> <li>-Visualisation : OLAP, Dashboards, Real-time information monitoring, t-SNE, reporting</li> </ul>	<ul style="list-style-type: none"> <li>- Predictability</li> </ul>
<b>Marketing intelligence</b>	<ul style="list-style-type: none"> <li>-Demand forecasting, sensing and shaping</li> <li>-E-business</li> </ul>	<ul style="list-style-type: none"> <li>-Simulation: FlexSim, ARENA, Witness, ARIS, etc.</li> </ul>	

will be low. Whereas organisations in adoption stage are aware of BDA technology, and possess a high level of Data Generation and Data Integration and Management Capabilities but not Advanced Analytics capabilities as Data Rich and Information Poor. Besides, only few organisations that possess a high level of all key BDA capabilities and fully integrate their business processes at the stage of routinisation. These organisations will be the leaders in BDA practice and are certainly Data Rich and Information Rich (Arunachalam et al. 2018). As (Vieira, Dias, Santos, Pereira & Oliveira 2020) argued that no study has

used Big Data concepts and technologies to store, integrate and provide real data to SC simulation models in the BD context, despite the benefits that such solutions are expected to bring to SCM. Furthermore the scope of most studies upon the applying of BDA models in SCM is reduced to a specific process, while do not consider all activities occurring in a SC.

## Conclusions and Future Work

In this paper we provide an overview about the interest of Big Data and Big Data Analytics capabilities in Supply Chain Management. While relying on this literature review, we aim to answer these three main questions: in what areas of SCM these amount of data are being generated?, in what parts of SCM, BDA is being applied?, and what kind of BDA models and techniques are applied in each part?. We also discussed the industry 4.0 and the role that BDA plays for its implementation. Hence with the growing and explosion of BD and its combination with another technologies such as IoT, smart systems, and artificial intelligence algorithms companies have to think differently in how they design and manage their SCs operations to compete better in the global market. In addition, several companies adopt a variety of Information and Communication Technologies for SCM (e.g. RFID, Enterprise Resource Planning (ERP), IoT, etc) to collect, manage and store their data. BDA capabilities are an efficient tools that enable companies to derive valuable insights from these data among SCM, by using three levels of analytics : descriptive, predictive, and prescriptive analytics. Their objective is to improve data-driven decision making and develop innovative ways that enable improving business efficiency and effectiveness. To do so there are several concerns concerning BD that we have take into account, such as, insufficient resources, privacy and security, lack of skills, etc. For further research in the future, we will address the challenges of BDA capabilities by proposing a full big data architecture for SCM that take into consideration all SC functions and BDA levels to help companies to have an overview of all their SC operations. As we have discussed in BD challenges and issues in SCM that the proposed BDA models in SCM is reduced to a specific process, while do not consider all the activities occurring in a SC, may we will handle this issue in the future.

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