Various Applications Dynamics of Big Data Analysis in Supply Chain Management

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Abstract. Contemporarily, with the rapid boost of the data quantity, big data analysis techniques have become a major tool to deal with issues in various fields. Among different research fields, supply chain management is one of fields that can be strongly improved and enhanced based on big data analysis concepts. In this paper, we discuss various applications and different implementation approaches for big data analysis in supply chain management. To be specific, the basic features of the big data analysis and supply chain management are introduced. Subsequently, the types of the analysis in big data concepts will be presented. Afterwards, the specific applications implemented in supply chain management are discussed. According to the analysis, the current challenges limitations are clarified. At the same time, the future prospects as well as the opportunity for the supply chain management based on big data techniques are demonstrated. These results shed light on guiding further exploration of big data implementation in supply chain management.

Keywords: Big data analytic; supply chain models; big data opportunities; the discovery of big data; supply data link.

1. Introduction

Major business entities in the world that embrace Big Data analytics (BDA) have seen a significant improvement in the efficiency of operations and offer an opportunity for new business transformations. It uses data and quantitative methods to make an informed decision. Big Data has leapfrogged traditional data handling by ensuring the new systems can manage to store, handle, oversee, decipher, and visualize data close to an Exabyte in a single year. Today, data is continually growing, and there is an estimation from data analytics experts that the data will expand close to a zettabyte annually. Due to the exponential growth in data, some companies have ventured into upgrading big data analysis, which enables institutions to improve their understanding of operations and generate new opportunities in supply chain management (SCM) [1]. Consequently, some researchers and practitioners such as Amazon and Walmart have used big data analytics to monitor, track, and secure business inventory that is unevenly distributed across the world.

With this in mind, the current exercise gives a comprehensive summary of big data extending to introduce the applications in sales and inventory. It also gives some big data processes, such as sourcing, manufacturing, warehousing, point of sale, and transportation.

2. Specific Application of Big Data

Big data application in business is a widely researched field from its emergence to its current growth endeavors. According to Berntzen Krumova, big data provides businesses opportunities that companies can use to strengthen competitive advantages and empower disruptive innovation. This includes data transformation, integration, analysis and visualization, and data acquisition. This author argues that the actual value of big data does not mean having a large volume of information running within the firm but the ability to analyze complex and vast sets beyond what the field could hold before. Qazi & Sher analyzes the topic of big data application in businesses, giving an overview of the specific application of big data [2]. Arguably, they argue that businesses embrace big data

systems to improve efficiency and, at the same time, minimize cost and resource consumption. Big data is applied to generate business value, extending to economically meaningful information through its analysis.

In conducting BDA research, the first point is the definition, which in this case of supply chain management, has various definitions resulting from multiple researchers. There is no specific method in data analytics because the method used is dependent on the problem [2]. Therefore, a problem should be first identified to determine the method to use. Following the problem identification, research is conducted to allow the best methodology to commence, but general guidelines must be followed for all methods involved. The typical analysis flow for big data analysis is shown in Fig. 1.

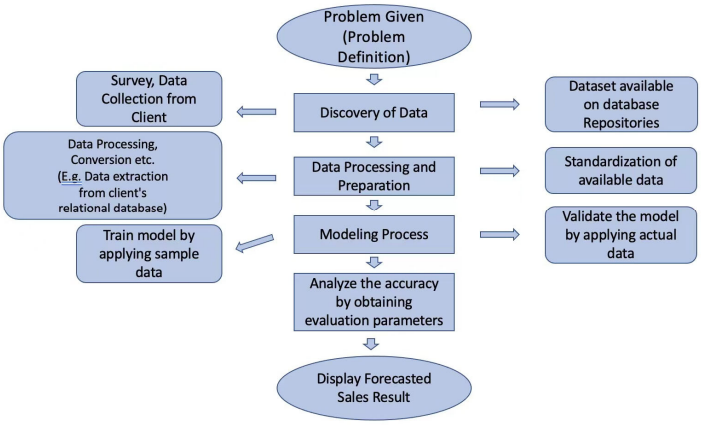

Fig. 1 A representation of big data flow processes.

The product determines which supply chain design model will be used in big data supply chain management. The operating model follows a strategic landscape of supply chain analytic opportunities. In reality, many institutions have invested in Big data analytics systems, but only a few can implement those findings. Consequently, institutions are unwilling to incorporate data science and supply chain management by linking the data to ongoing practices and applications in procurement, transportation, warehousing, and marketing.

2.1 Sales, Inventory, and Operations Planning

Planning is the most crucial part of the supply chain because it uses data-driven analysis with the help of Enterprise Resource Planning (ERP) and SCM planning tools. With big data analytics in place, an organization can manage to track real-time demand for items through the available internal and external sources [3]. In return, the SCM is shaped smoothly. Supply chain management can use the same approach electricity companies use to store and distribute electric energy depending on demand and availability. In SCM, the available inventory, production volumes, and point of sale data (POS) help decision makers act accordingly and plan for any gaps arising from the difference in demand and supply. Those factors determine other market dynamics such as price drops or price hikes, whether to launch a promotion or list new products to manage the rising competition.

In addition, retailers can use the data to effectively plan how to meet market demands, as demonstrated by Blue Yonder's invention of a system that can predict market probabilities through numerous variables [4]. With such a system, companies can increase their sales forecast accuracy and reduce unwarranted costs arising from poor supply channels. The system creates an avenue where the inventory aids retailers in tracking stock levels and stock-outs, giving the company a clearer view of logistics.

Another example is how baking companies use this data by incorporating sunshine and weather forecasts to predict the expected demand for certain goods based on factors influencing their consumption. The effectiveness of such information is relevant in reducing wastage and general supply chain management costs. International companies such as Amazon have used BDA to successfully improve their supply because they predict daily demands of certain goods and pack them even before the customer places an order[4]. Through BDA, companies can use inventory data and

other factors to try and encourage customers to purchase goods on stock when other products are out of stock.

2.2 Sourcing

Traditionally, companies have relied on the procurement and supplier data collected for minimal activities of the sourcing process. Modern supply chain management, data can be collected in real-time and show changes in the normal delivery schedules. The use of the internet through google trends has impacted the distribution process because suppliers can track issues such as strikes, bankruptcies, fires, and many other factors that lead to interruptions in a smooth flow of supplies prompting an intelligent manager to take decisive actions and counter competition. Some pharmaceutical companies have used data analysis to make strategic plans for packaging goods according to the customer's preferences.

The data can be used to determine updated costs of goods and commodity prices and helps to educate customers on the right choice of suppliers for any project. A client can log in to a supplier's website, evaluate the quotations compared to the competition, and decide which offer best suits their needs. This is, of course, made possible by the use of data analysis [4]. The supplier can use the breakdown of warehousing and transportation cost data to highlight the expectations from a logistics company because he has an idea of the price range of the outsourced service.

2.3 Manufacturing

Manufacturers can significantly benefit from big data analytics. Factory parameters such as assembling, operations, and the like can be analyzed, and the causes of concern determined and planned for even if they do not happen immediately. The use of the internet has impacted all sectors of the business world [5]. The use of cameras by agronomists to monitor the growth and development of seeds in real-time has enabled them to gather and analyze accurate data, which helps them determine how crops behave under changes in variables.

That information is used while determining which crop should be planted, when, and where [5]. Eventually, technology is not slowing down, but innovations will continue to surface, and things such as cameras and sensors in the manufacturing sector will improve the expected manufacturing opportunities.

2.4 Warehousing

Regarding to logistics, the cost is critical in determining a warehouse's where, why, and how. Cost-based analyses are the driver of the heavy investment of companies in technologies that give them an upper hand over their competitors. ERP data has helped companies utilize warehouses by using different approaches to make the arrangements, picking, and general staffing easier [5]. For example, the use of high-rack bay warehouses where the pallets are automatically rotated according to the expected orders for transportation and the use of chaotic warehousing where the available space is utilized to minimize the distance of goods on transit as being near to workers. A typical sketch is shown in Fig. 2.

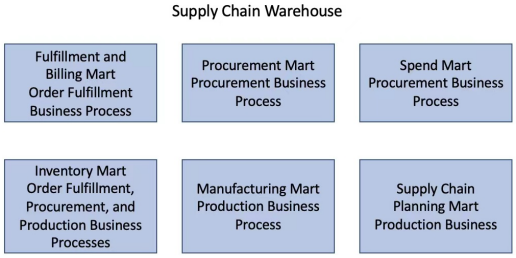

Fig. 2 Representation of big data within supply chain warehouse

Technology is a factor that cannot be overlooked in manufacturing. Some inventors are looking into how technology can be used in forklifts to collect sufficient and real-time data concerning the weight of shelves, temperatures, sizes, and so on to help determine and monitor waste in warehouses.

Root-cause analysis can also be made possible by analyzing the data collected in real-time by automated forklifts designed to record work videos. The new 3D technology has improved warehousing activities because it can be used to effectively design new ways of increasing storage space, even in old warehouses [5]. This technology promotes picking efficiency and offers productivity by easing the workload.

2.5 Transportation

GPS technology on trucks has helped improve loading efficiency because trucks are allocated loading bays in real-time; hence, no congestion might lead to confusion and slow work motion. Fuel consumption has been a significant concern for courier services, but through the help of analyzing fuel data, companies can now save on fuel without compromising on service delivery. Moreover, data analytics is essential in easing the delivery of goods to customers because with real-time truck location combined with the current traffic data, and a delivery driver can prioritize customers within the green zone as they await traffic to clear in other regions. Further, the data mined is successfully used t reduce delivery attempts because the company can accurately predict when the customer is more likely to be at home..

2.6 Point of sale (POS)

Retailers have used data-driven optimization to have a competitive edge over other competing brands. Real-time shelves-space optimization has led to improved efficiency in stores. Through advanced analytics, retailers can place fast-moving goods in high-end areas to attract more sales. Further, it can help track the effects of clustering related goods in high-end areas.

However, the most significant challenge lies in stock issues in retail stores. The use of manual monitoring is time-consuming, and the available systems, such as RFID tags, are costly for individual stores [6]. Retailers use data analytics to monitor the sales flow of certain goods. A sensory message is sent to prompt the staff to check on stock-outs whenever a particular product is not purchased within a specified period. Other reliable methods of monitoring stock levels include using cameras, installing weight sensors on shelves, etc. The examples above paint a clear picture of how data analytics has greatly improved the efficiency of service delivery in supply chain channels making data analytics an essential part of moving supply chain management to the next level [6]. The drawback for making organizations is the lack of a structured strategy on how to use data analysis to move the company to the next level. The companies must adopt a more desirable approach and commit resources to invest in new technologies.s.

3. Types of analytics in BDA

There are four main types of analytics in Big Data Analysis, including diagnostic, descriptive, prescriptive, and predictive analytics. The categories are presented in Fig. 3.

- Diagnostic analysis. This is the most advanced analytic method and relies on the gathered information to analyze the behavioral conduct of customers, employees, shareholders, and the like. The analysis might use probability theory, a search of data patterns, data filtering, and others to complete the task [6].
- Descriptive analysis. This analysis focuses on past events and their implications for the supply chain. Analysts use this method to study the current proceedings and relate them with past occurrences to predict the expected outcomes.
- Prescriptive analysis. These are predictions based on data to determine the expected outcome and propose actions that should be taken to avert the situation [7]. They also help in what-if situations and are associated with optimization and simulations.
- Predictive analytics: This analysis uses real-time information compared with historical data to give probable outcomes for the near future [7]. The analysis is based on machine learning techniques and computational algorithms of data mining.

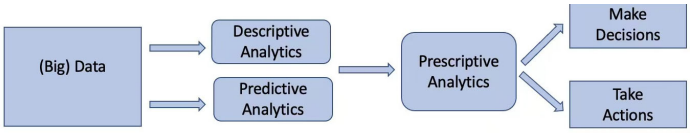

Fig. 3 Categories and Features of Big Data Flow

4. Applications of big data in Supply Chain Management

Big data analysis has, in no doubt, improved business optimization in multiple areas. In supply chain management, various significant improvements can be credited to data analysis. First, carefully analyzing big data has enabled organizations to smartly project inventory. Big data has helped businesses capitalize on opportunities as soon as they arise because they can predict trends and inventory fluctuations as soon as they happen and act accordingly. Secondly, through sensors and other improved technologies, industries such as pharmaceuticals, food, agriculture, and the like that depend on temperature control to preserve the quality of products can collect and analyze data in real-time, which in return allows for any actions to avoid damages [8]. Thirdly, GPS makes order fulfillment and real-time tracking possible through GPS, enabling the fulfiller to access traffic and other road hazards to avoid snarl-ups [8]. In addition, customers can get alerts for their expected delivery times. Data analytics makes delivery routing easier, enabling fleet managers to work swiftly. Forth, BDA helps to improve machine maintenance and avoid machine downtime due to poor maintenance, aging, and other issues related to inappropriate servicing [9]. Research indicates that close $50 billion a year is lost due to machine breakdown. Using sensors is a credible way to track production, schedule maintenance, and send alerts whenever the machine is not functioning according to expectations.

5. Challenges in Adopting Big Data Analytics for Supply Chain

According to Maheshwari et al, the challenges of adopting BDA for SCM are numerous and can be grouped into two categories; organizational challenges and technical challenges [10]. First, organizational challenges are those issues that affect the employees and make them not achieve their goals. These include but are not limited to time-consuming, lack of resources, security concerns, lack of skills, behavioral issues, and issues of return on investment [10]. Time is crucial in any business, and the amount of time spent analyzing big data is a cause for concern for many institutions. BDA requires a significant investment to acquire, maintain, and train staff using the new technology. It takes time before the company can enjoy ROI. It is risky when the company is sharing data across distribution channels because cyber-attacks are threatening [11]. Notably, the behavior of decision makers is tested when there are unprecedented supply chain channel changes, which might affect the business depending on the actions taken.

Secondly, technical challenges are those problems related to data and professionalism. Issues such as lack of skills, data quality, and data scalability are the most common challenges [11]. The quality of the data store should be consistent to allow data analysts to use their techniques and make informed decisions. The lack of required skills to analyze the data renders the collected data useless because the company is not benefiting from changes in its supply chain. The incapability of companies to switch from traditional data storage to cloud servers has limited the storage and use of BDA.

6. Opportunities for Big Data Analytics in Supply Chain

A compelling reason for adopting big data analytics is to solve the underlying issues in supply chain management that traditional methods have failed to address [12]. The supply chain is complex because it involves moving, storing, and distributing goods. The unstructured flow of work in process, inventory, financial documents, raw materials, finished goods, and returned goods are interlinked under one system [13]. Managing this data is essential; hence, it creates an avenue for BDA to help

solve and interpret it. As organizations aim to take their operations globally, supply chain management has faced traditional management challenges of interpreting the data because they lack proper management channels. Today, information flows electronically from one supply chain entity to the main organization, further analyzing it for better results..

7. Conclusion

In summary, the use of Big Data Analytics in supply chain management has revolutionized how businesses operate across different sectors of the economy. Data analysis has improved the efficiency of services through the internet to ease ways of doing business. It is evident from the examples given in the paper that BDA has contributed significantly to cutting costs because of available predictive and diagnostic analysis to help determine what to do best. The advantages of BDA in SCM are much greater than the high costs involved in investing in the system.

Nevertheless, extensive data analysis reflects some limitations to supply chain management. First, data security from malicious access is dangerous to large and small-scale businesses. Transferring data within the supply chain protocol is another major limitation in this subject. In addition, a discrepancy in data collection within the SCM departments marks another limitation that business firms face. In the future, individual system developers should embrace a framework in consideration of limitations and best practices. Overall, these results offer a guideline for safe workplaces.

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