Big data sustainable supply chains

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Contributor: Joash Mageto

Sustainable supply chain management (SSCM) has received much attention in the decade ending in 2020 due to an increased awareness of climate change and environmental and social issues across the globe. SSCM requires firms across a supply chain to report not only on profits but also on environmental and social performance. SSCM can be improved by utilizing big data analytics, as such, the paper investigated how big data analytics can be used to enhance SSCM practices in manufacturing supply chains

Keywords: sustainable supply chain management ; big data analytics ; Toulmin argumentation model

1. Introduction

To achieve the objectives of SSCM, firms should set long-term goals on sustainability, be transparent in their reporting, develop a culture of sustainability and manage supply chain risks appropriately [1]. With globalization, manufacturing supply chains have become complex, making it difficult to monitor the sustainability practices of every firm especially in developing countries where there are no existing regulatory frameworks. The complexity of manufacturing supply chains implies that some firms might get away with a socially and an environmentally irresponsible behaviour undetected especially in issues such as child labour [2]. The huge amounts of data collected are known as big data and can help minimize the complexity of monitoring sustainability practices in manufacturing supply chains.

Firms that implement SSCM are likely to reduce operational costs, improve their image and monitor their environmental actions by pursuing sustainability goals [3]. In addition, data driven decisions are likely to increase the effectiveness of not only the individual enterprises but also their supply chains in the implementation and monitoring of SSCM goals [4][5]. The application of BDA is likely to result in improved operational performance through accurate and faster decision making within the supply chain, especially when there is access to real-time data [3][6][7]. BDA can drive efficiency and effectiveness in supply chain management in terms of improved demand management, faster new product development, better supply chain risk management, better supplier management and development of efficient and robust supply chain designs, thus supporting the sustainability agenda [5].

Many researchers have examined the concept of big data analytics from various perspectives. For instance, the development of BDA capabilities in firms [5], BDA applications in SCM (Nguyen et al., 2018), BDA applications to logistics [8], BDA applications in raw materials flow in manufacturing operations [9], BDA and decision making in SCM [10], the effect of BDA capabilities sustainable supply chain performance outcomes such as sustainable product development (Jose et al., 2020) and dimensions of big data databases [11]. analytics?How does big data analytics enhance SSCM in manufacturing supply chains?What are the challenges that inhibit the implementation of big data analytics in manufacturing supply chains?

2. Big Data Analytics in Sustainable Supply Chain Management

Big data and data analytics are identified as “big data analytics” and characterized by the “5Vs” of volume, velocity, variety, veracity and value [12]. Data processing is identified as an important dimension of BDA; it includes real-time continuous collection of heterogeneous data using intelligent devices, modelling, data mining and analysis from various perspectives to provide new insights [13][14]. Prior literature [5] confirms that big data can only be collected across the supply chain and processed to develop insights for decision making if there is transparency in data processing. Openness and accountability will allow for the supply chain members to make decisions collaboratively based on the insights from the data analytics.

The security dimension of BDA requires that the data collected and analysed should be protected from unintended use by supply chain partners and from external attacks [15]. As per the security dimension, the systems used should allow for authentication for access to the data and encryption when the data is transmitted within the network. BDA security

capabilities should also include fraud analytics for early detection of unethical conduct. The security dimension should also help maintain clear security and privacy laws that govern how the data is collected, handled, analysed and reported for the benefit of all supply chain members [16][17].

Reporting provides a basis from which regulators can be able to institute control measures [11] to improve SSCM in manufacturing supply chains. This implies that reporting should include the social aspects that supply chain partners are engaged in, such as capacity development, education and skills development [11][18]. The decisions made should meet the requirements of all stakeholders: the need for all the supply chain members to participate freely, collaboratively and cooperatively in BDA implementation at the various processes of the manufacturing supply chain. In addition, there should be capacity building in the communities in terms of technical skills, and the BDA reports should be made available for reusability for the common good of society and all the stakeholders.

Analytics dimension is another dimension of BDA. One of the methodologies used to perform BDA analytics is machine learning algorithms, which can include predictive analytics and complex modelling [19]. Predictive analytics are considered to be important as they can result in new insights that can improve supply chain visibility, resilience, cost savings and information transparency, which are important in SSCM [19]. In addition, [6] argued that predictive analytics can allow for supply chain integration and promotion of sustainability across the supply chain.

The Integration dimension of BDA allows for the seamless connectivity of various supply chain partners' systems to share data and subject it to analytics for generation of insights. Integration occurs when quality data is collected continuously from each of the supply chain partners and shared in real time [14]. The integration should also be possible with external stakeholders, such as the government, so as to collect rich data. Integration as a BDA dimension results in quick response, seamless compatibility of systems and processing of data from various sources and types to promote SSCM objectives [15][20].

Finally, the economic dimension requires that big data analytics be economically viable in terms creating value for the supply chain members as well as the various stakeholders. Specifically, big data analytics should result in operational cost minimization, thus supporting the study in [16]. To create value, supply chain members should be ready to commit financial resources to invest in technologies and data infrastructure, which are aligned to the economic, social and environmental objectives. This implies that big data analytics should not only be commercially enhancing but also environmentally and socially to promote sustainability across the supply chain.

To lay foundation for theclaim, this study highlights that data is a medium of integrating the various links of supply chains through its collection and sharing across the supply chain. The data is expected to be quality for effective decision making across the supply chain (Brandenburg et al., 2016). The application of BDA enhances the transparency facet of SSCM by creating high visibility across the supply chain, which promotes a win-win situation for all stakeholders [21]. Thus, BDA enhances SSCM, as it encourages transparency through the sharing of data on processes and activities across the supply chain.

To achieve the high-level analysis, advanced analytics that utilize simulation and optimization models to understand the likely effects of every action are required ([22]. BDA, as demonstrated through the dimensions inSection 2.4, has technologies and analytics capabilities to collect data across the supply chain and perform analytics to develop insights that can achieve data-driven decision making regarding costs and benefits from a sustainability perspective. Thus, data analytics is required to understand the effect of each of the activities and classify those that support sustainability to be enhanced and the ones against sustainability to be eliminated or minimized. This finding is supported by [19] who emphasize the importance of predictive analytics in supply chain decision making regarding cost savings and competitiveness.

The analytics are likely to result in cost savings, reduced health and safety costs and shorter cycle times and enhanced reputation [21][19]. In addition, [6] argued that big data can improve the economic dimension of a firm through reduced operational costs, thus creating competitive advantages. Further, [23] also highlights that firms should build BDA capabilities which are known to support sustainable product development initiatives. Therefore, firms can implement specific sustainability initiatives from an informed perspective based on the insights obtained from big data analytics.

The application of integration and interoperable software for data sharing across the supply chain includes real-time analytics capabilities of data from internal and external sources (such as social media platforms which generate data at high velocity) to help draw insights based on mentions of firms from a particular supply chain. In addition, data analytics on external data is also likely to help in risk management by identifying risks related to supply chain disruptions from protests, traffic, natural disasters, trade wars, political conflicts and even scarcity of raw materials as well as pandemics like COVID-19. As such, [6] supports that there is a relationship between big data analytics and sustainable supply chain

management, whereby big data analytics tools promote the sustainability of manufacturing supply chains by transmitting real-time actionable reports from the collected data. Thus, identifying supply chain risks earlier using insights from BDA and mitigating them promotes SSCM.

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