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Scope of big data analytics in green supply chain management: a review

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Abstract

In the modern era, the specialists working in the supply chain arenas are engulfed with enormous amounts of data, which has made them think out of the box and probe more into the sources of the data and techniques of analyzing and organizing the unstructured data. The new bud scholars and professionals have endorsed big Data Analytics (BDA) lately as a decisive green supply chain management facilitator. Research in this particular area is still to be explored to the fullest. The findings of the research are still in the introductory stages. Our study comprises an organized literature review of 42 significant papers published in the previous 18 years, which performs thorough reasoning and outlines three types of GSCM field: green product innovation, reverse logistics, and green procurement. The study presents the scope of BDA in these respective areas of GSCM. The study helps to portray the extent of usage of BDA tools in distinct GSCM fields. The literature review also sheds light on certain gaps in the research work. It caters to the directions for future work in the dedicated field.

Keywords

Big data analytics, Reverse logistics, Green procurement, Green supply chain management, Green product innovation

Imprint

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1 Introduction

The term sustainability was first combined with the Earth Summit at Rio in 1992. The United Nations Environmental Programme (UNEP) was established to look into the matters related to the environment and manage the business linked with it. After the establishment of UNEP, several steps were taken to promote the idea of sustainability. According to Rao P, Environmental Management System, Cleaner Production, Responsible Manufacturing, and green supply chain management were emphasized and managed to entice all stakeholders [1].

Green Supply Chain Management (GrSCM) encompasses several important subunits. Four niche fields work by being dependent on each other and help in achieving the company's goals. According to Venu, GrSCM is an aggregate of Reverse Logistics, Green Distribution, and Green Manufacturing/material management in Figure 1.

Green Supply Chain has directly connected both Supply Chain Management (SCM) and environmental management. The inclusion of the term 'Green' in supply chains has helped the industries monitor the supply chain links and environment. The introduction of GrSCM is driving the companies' operation towards the idea of sustainability [2]. This concept has made industries adopt green initiatives, which are the need of the hour for the present world.

Mark & Douglas, as an exhaustive volume data, which is integrated with high velocity, and variety, have mentioned big Data (BD). These qualities have made Big Data a standout tool, which has enhanced insight and decision-making.

BD has incorporated 11Vs in its arsenal, Figure 2 shows among them 5V, which are (a) volume; it reflects the enormous bulk of the data, which has vital records linked. (b) Velocity, it signifies the pace by which data is being spawned and delivered. (c) Veracity is a vital attribute of BD, which intensifies the importance of the attributes of data and reliability over the different data origins, as stated by White. (d) Variety, it demonstrates the multiple origins from where data has been generated [3]. These data can be structured or unstructured, as observed by Wamba, Akter, Edwards, Chopin, & Gnanzou. (e) value, this dimension was added by Forrester. It has helped to track down the economic surplus generated from the data.

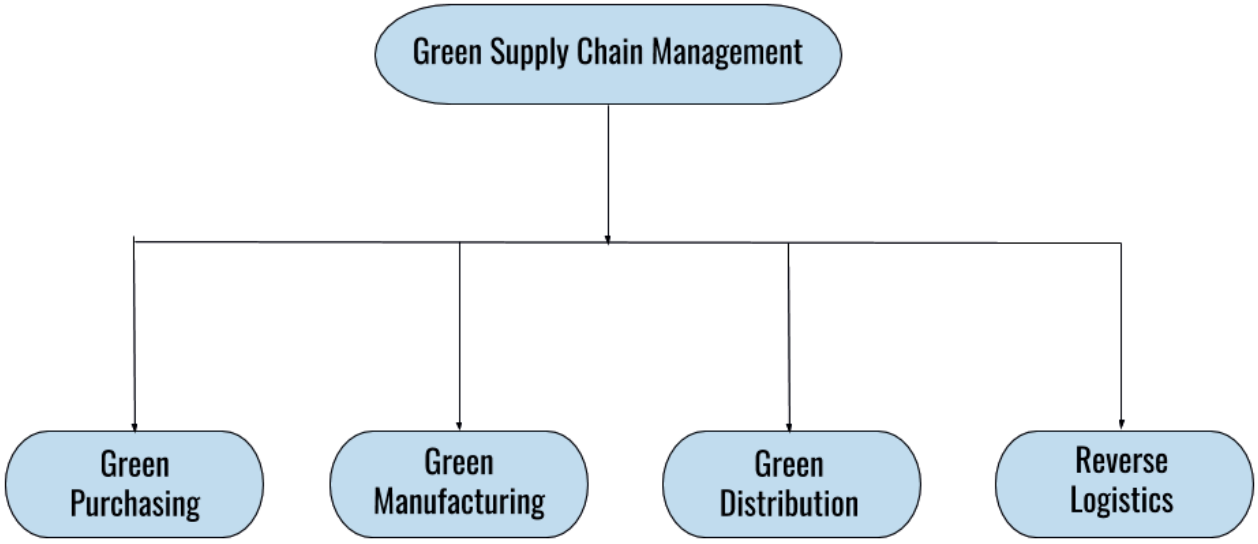

Fig. 1. Four fields of GrSCM

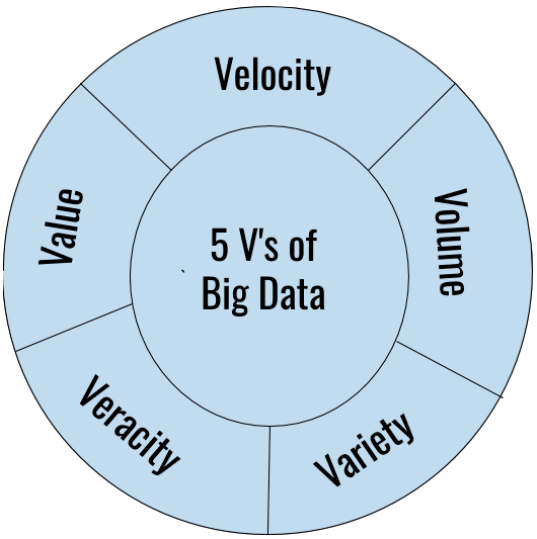

Fig. 2. 5 V's of big data

The seriousness of BDA has been accentuated by Waller & Fawcett for Supply Chain Management [4]. They have proposed the term "SCM data science referring to BDA, as the application of quantitative and qualitative methods from various disciplines in combination with SCM theory to solve relevant SCM problems and predict outcomes, taking into account data quality and availability issues."

The IoT and Big Data have displayed immense potential to be deemed a future technology that will affect people's lives in the evolving world. The operations executive associations have begun their probe to filter out the needful insights and prospects, as researched by Accenture.

The data in the present age majorly being contributed from the suppliers and buyers end. Nonetheless, the majority of the SCM findings are still not being made by incorporating big data attributes [5]. The need of the hour is to start considering the aspects of supply chain modeling and big data, as researched by Kaur & Singh.

The given research work hovers around certain specific areas related to Green SCM. It undertakes the following questions: 1) What are the multiple regions of Green SCM, which are legitimized by the BDA tools and attributes. 2) What is the present status of BDA tools that are being incorporated in Green SCM.

2 Research methodologies

To deliver a comprehensive Literature Review for the research papers, presenting the purview of Big Data Analytics in the GSCM, we managed to gather the data from the sources like "Web of Science," "Scopus," "Science Direct," and "Research Gate." There are a few distinct keywords, which were at the center of at-

tention, such as "Green Supply Chain linked with Big Data," "Big Data Analytics with the Sustainable Supply Chain," "Big Data integrated with logistics," "Big Data and the Green Purchasing." Our work was inclined with the 42 published research papers within the span of 2002 to 2020 [6]. We have gone through the research procedure and the Literature Review of the segregated 42 papers. The insights were displayed from the paper we referred to with proper explanations. At the very last of our analysis, we ended with the conclusions and future scopes to bridge current research gaps. Figure 3 shows the research methodology.

3 Literature review

3.1 Overview of green supply chain management

GrSCM has its underlying foundations in both Supply Chain and environmental management. Including the 'green' segment gracefully to supply-chain management tends to impact and connect the supply chain and the indigenous habitat. The idea of SCM is reliant on the objective of the specialist.

SCM has demonstrated Min & Zhou, which has grown approximately a customer-centric perception and drives changes in the overall organization's external and internal linkages and then seizure the harmony of inter-organizational integration, inter-functional, and coordination. With increasing numbers of concerns regarding environmental pollution, organizations are addressing the concept of GrSCM and industrial development as one [7].

GSCM has several advantages, such as cost reduction and supplier involvement in the process decisions that encourage eco-innovation, according to Rao P. It further helps in reducing the consumption of energy and costs related to the material, as stated by Zhu and Sarkis. Authors Fuentes-Fuentes, Albacete-Sáez, & Lloréns-Montes established how greening a process results in positive economic outcomes. It helps in reducing costs, which in turn results in growth in the profit and market share [8].

3.2 Big data analytics

The outset of digital technologies and tools has helped to consider the data and its analysis. The emergence of the Internet of Things (IoT) and other auto-

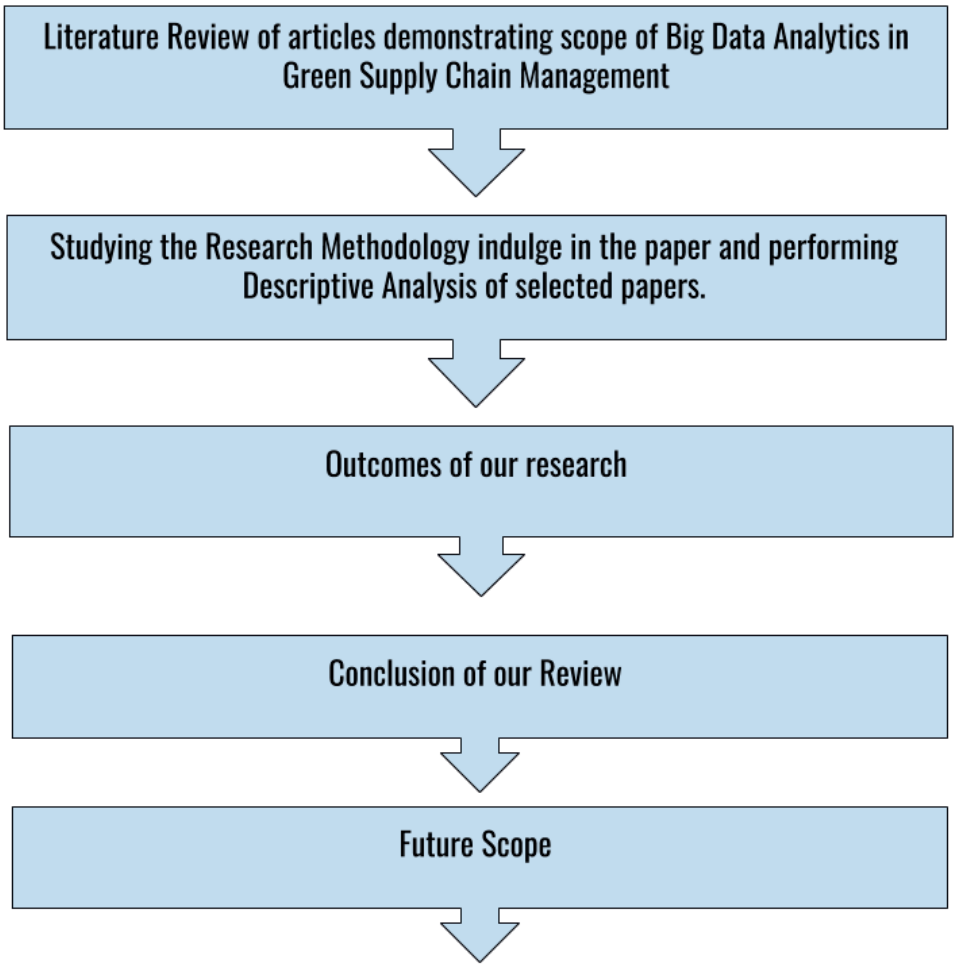

Fig. 3. Research methodology

mated tools and Web 2.0 with the Industry 4.0 have made the visualizations of Big Data quite easy, as observed by Hui & Silvana. This research has enormous scope and is very popular among upcoming scholars. Gigantic unstructured data are now gathered from various origins. The sources include ERP (Enterprise Resource Planning), scattered production surroundings, orders, and freight logistics, patterns of buying preferred by customers, social media records, the lifespan of articles and their operations, and high-tech data directed sources like GPS (Global Positioning System), RFID (Radio Frequency based Identifications) spotting, vigilance data and many more. The industries currently are negotiating with the data files, which fall under the scope of 4Vs; volume, veracity, variety, and velocity [9]. The bigger datasets of these criteria become very challenging to work with, and visualizing them to hand over fruitful results.

In light of itemized writing surveys by past writers, it is understood that big data finds tremendous applications fundamentally in logistics and procurement. Researchers likewise found that the greater part of the research performed on big data concerning GrSCM is conceptual and theoretical. The analytical models that have been used in big data are at a very nascent stage. In addition, these models incompletely catch the big data in the field of logistics and sustainable procurement. In this manner, creators accept a colossal hole in connecting big data to improve operations, such as logistics and procurement in GrSCM, as recorded by Kaur & Singh.

The financial performance was analyzed by Feng et al. of a Chinese manufacturing company through "data-driven supply chain capabilities." The proposed structural equation modelling for this study [10]. The results indicated that there is a positive relationship between supply chain responsiveness corresponding to the changes in the demand from markets or consumers that are buckled up with the organization's financial performance."

Analysis was executed by Arunachalam & Palanichamy on the potentials of the BDA integrated into the supply chain realm, and they constructed a prototype, which was settled on the capability maturity [11]. They spent their time analyzing the published paper from 2008 to 2017. They acquired the knowledge of Big Data and its capacity in the region of the SCM. They come with future scopes and potential research gateways in the same field.

3.3 Industry 4.0

Industry 4.0 was adopted to incorporate digital transformations, mainly in manufacturing or production organizations. It inducts various categories of high-tech and breakthrough concepts. At the same time, it paves the way for inculcating BDA in GrSCM, according to Jan Ola Strandhagen et al.

Some of the broadly used technologies in industrial manufacturing are:

i. The very first is the Identification tool. It is known as Auto ID, which helps elicit the characteristics of an object. It is also embedded with sensor technology that helps to gather the real-time data compilation from the appliances present in the workplace [12].
ii. Virtual Reality (VR) has directly helped the operators responsible for the functioning of machinery present in the manufacturing and assembly line.
iii. Big Data analytics helps to squeeze out the invaluable information present in the unstructured data, which are available in enormous quantities.
iv. Autonomous vehicles and robots for easy transportation along with saving fuel along with time.
v. Artificial Intelligence (AI) has enhanced the efficiency of the process by integrating automation in the simplest of procedures. It has influenced the decision-making and operations without the physical mediation of humans.
vi. Cloud computing, through which cloud manufacturing has become capable of interlinking the production sources, has directly optimized the internal and external logistics.

4 Outcomes of literature review

4.1 Green product innovation

Respective governments and society have been pushing for green innovation on a large scale owing to the scenario of the surge in pollution level, which has triggered the depletion of natural resources. The causal factors have been probed by Zailani, Iranmanesh, Shaharudin, Govindan, & Chong, which were anchoring for the adoption of green innovation [13]. They analyzed the market conditions and studied future demand. It was evident from their research that an organization's environmental governance and internal initiatives are accountable for the green innovation push.

Industries opt for Green production only when the R&D results predict an operational improvement, fi-

nancial gain, and enhancement of their market share by gaining a competitive advantage, as stated by Chiou. As environmental performance has become a factor to look after for the industries, the implementation of green practice has become necessary for them, as observed by Chithambaranathan, Subramanian, Gunasekara, & Palaniappan and Weng, Chen, & Chen. The integration of green production and its results linked with environmental performance has influenced green supply chain management, as researched by Chiou. Partner suppliers will play an enormous role in enhancing the environmental attainment factor by adopting the green supply, as Chithambaranathan, Subramanian, Gunasekara, & Palaniappan studied [14].

Green product and the Green process involved in manufacturing along with Big Data Analytics are together responsible for the green innovation, which has positive outcomes in terms of reduction of consumption of energy, according to El-Kassar & A.-N. Green innovation has sparked the results for the recycling of wastes, green product designs and controlling of pollution emission, as observed by Chen, Lai, & Wen.

Adopting green innovations and gaining competitive advantage is highly driven by corporate environmental ethics, as researched by Peng & Lin. Sustainable goals of the industry will be fulfilled when they include green innovation and management in the nucleus of the functioning of an organization [15].

Big Data is a new tool whose influence over the various sectors is being appreciated lately. It has projected the potential to impact the environment positively once blended with supply chain and green innovation, as studied by Cajaiba-Santana and Huang et al., Dubey et al., Roßmann, Canzaniello, von der Gracht, & Hartmann, Papadopoulos, Gunasekaran, Dubey, & Fosso Wamba.

4.2 Green purchasing/procurement

The basic idea of adopting the green model of the supply chain by the industries is to curb the carbon footprint and promote environmentally sustainable procurement. The measure of carbon generated from the side of suppliers should be monitored. Selection of suppliers must be done on these criteria. Therefore, to help this thought, certain sustainability benchmarks were included to assess the suppliers' carbon footprint [16]. The few criteria like fuel efficiency, fuel used, packaging material used, the medium of transportation, and distance from the plant are considered, as recorded by Seuring & Muller, Presley, Meade, & Sarkis, Ciliberti, Pontrandolfo, & Scozzi, Kumar & Jain, Bai & Sarkis, Hsu, Chen, & Chiou.

Selecting Green Suppliers is deemed to be a highly important task in order to adopt Green Procurement; according to Raut, et al. BDA has played a crucial role in the assessment of the environmental performance of the suppliers by inspecting the historical data, as stated by Liou, Chuang, Zavadskas, & Tzeng, Singh, Kumari, Mishra, & Malekpoor.

For illustration, optimization and machine learning were the critical tools in segregating the suppliers with low or little carbon discharge, as observed by Singh, Kumari, Mishra, & Malekpoor. As researched by Singh, Kumari, Mishra, & Malekpoor came up with a framework for cloud computing of big data to study the data linked with the complete procedure of developing cattle in beef farms. The study incorporates the data related to cattle's age, average weight, breed, diet, and many more. Using the above information, AI can rate every beef farm according to its supplier selection norms. Optimization scrutiny and TOPSIS were used to aid the settlement between carbon footprint and meat quality. It helped to cull the high-quality beef with a nominal carbon footprint at affordable prices, as studied by Singh, Kumari, Mishra, & Malekpoor.

Collaboration with the suppliers is regarded as another important step in Green purchasing. The sustainable goals and environmental criteria must be communicated with the vendors and suppliers to achieve the targeted, sustainable limits and business information. BDA aids in the proper sharing of the information with the suppliers and efficiently contributes to environmental collaboration, as Raut et al.

4.3 Reverse logistics

The term 'Reverse Logistics' has attracted the attention of organizations. It has created favorable conditions for the industries to generate new income origins and present their corporate social responsibility (CSR) via environmental, social, and green activities, as stated by Hui & Silvana.

Reverse logistics was introduced to manage the reverse flow of materials to maximize their worth, as Kannan, Pokharel, & Kumar observed. Products exit from the desired supply chain for various reasons, such as item recalls, commercial returns, reusable products, warranty returns, end-of-life returns, and end-of-use returns, as researched by Han & Ponce-Cueto.

Fuzzy TOPSIS and Interpretive Structural Modelling (ISM) were used to navigate the segregation procedure for electing the outclass third-party logistics providers, as Kannan, Pokharel, & Kumar studied. This case study based on the manufacturing industry in India has presented the efficacy of the ISM and fuzzy TOPSIS.

As recorded by Hsueh & Lin came up with a new model to rate alternatives for enforcing the "sorting process of reverse logistics in the downstream photovoltaic industry." The new model has merged the various attributes like the opportunities, benefits, risks, and costs.

The products, which do not follow the predefined life cycle and exit from the supply chain because of the reasons mentioned above, the end-of-life of these products, can be assessed using Big Data Analytics. It helps in remanufacturing, reuse, recycle, inspection, and sorting of the products. Furthermore, big data helps gather real-time analytics of vehicles and materials and facilitates assessing the locations to find best-suited routes for the transportation of materials, as to Jan Ola Strandhagen et al.

5 Conclusions

The study has inspected 42 papers demonstrating the scope of integration of the BDA and GSCM. By conducting a literature review, we were able to scrutinize three aspects related to GSCM that are connected with the BDA. These fields were Green Product Innovation, Green Purchasing/Procurement, and Green Logistics. Big Data Analytics has presented the window of scope for enhancing the veracity of decision forming. It has become a potential tool for forecasting future trends by using the data linked with the processes.

The systematic study of the literature review has displayed two connotations. Firstly, we presented comprehensive insights into the research advancement made in one of the emerging fields, BDA integrated with GSCM. Our study reinforces the perception of BDA in GSCM and interprets the aspects of the BDA in distinct GSCM areas. To be precise, our detailed analysis objectifies that this field is premature and demands the considerations of the experts coming from contrasting backgrounds of education to probe the potential aspects of the field.

Moreover, the scope of green operations can be diversified. It can hop from internal environment handling to foreign GSCM ventures. For example, integrating their supplies, vendors, and customers with the GSCM will enhance environmental performances.

6 Future scopes

We tried to present the forthcoming opportunities that can be explored in the research field through our study. Foremost, the current analysis has only tried to highlight the capacity of BDA in particular GSCM operations. The influence of BDA in GSCM may help present the interrelation of various operational activities linked with GSCM. Therefore, forthcoming research perspectives can cater to a comprehensive structure on the utilization of the BDA in organizations' long-term GSCM executions.

Big Data is still showcasing the potential of applications in the different sectors. The respective articles do not comprehensively reflect the new-fangled BDA knowhow and their scope in GSCM. Thus, the upcoming scholars should concede the utilization of the surfacing BDA capabilities and their impressions on GSCM.

Conflict of interest

None declared.

Author contributions

The authors read the ICMJE criteria for authorship and approved the final manuscript.

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